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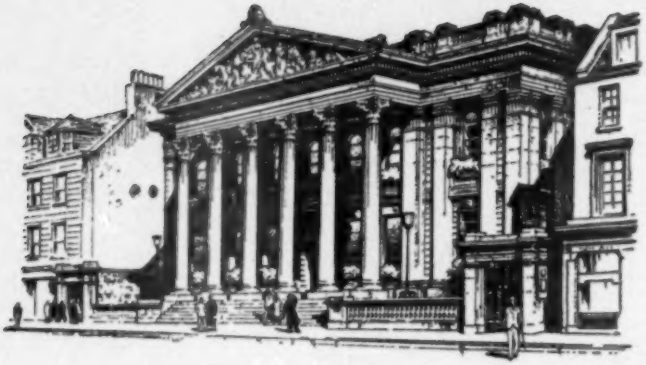

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COASTAL CORROSION FORMS IN LIMESTONES AROUND THE BAY OF BISCAY

ANDRÉ GUILCHER

THE problems of karstification in limestones have been discussed by a number of geomorphologists, for Mediterranean as well as for tropical countries; and, very recently, a detailed and comprehensive study was devoted to the karsts of North-western Europe [1].

But other problems arise from the morphology of limestones occurring along shores, either lying in the intertidal zone or washed by spray. Here, one should not perhaps speak of karstification in the strict sense of the word, because the corrosion of the rocks does not include an underground circulation of water: it is exclusively superficial, but it creates, however, a particular morphology which does not derive from the mechanical action of the waves. Some geologists described, before the World War II, curious zonations in coastal limestones on the shores of Oahu (Hawaii) [2], in Farsan archipelago (Red Sea) [3] and in other warm seas. During the postwar years, there have been other descriptions of some parts of the Welsh, Irish and English coasts [4, 5, 6], the Crimea[7], the Mediterranean[5, 8], Morocco[9], Portugal[10], Florida[11], Bermudas[12], the Red Sea[13], Western Australia[14], Madagascar[15, 16], Tuamotu archipelago[17], etc. On the other hand, two assessments of general problems have also been published: the first one is an attempt to define several types of zonation on the calcareous shores of the world in relation to different climatic environments [5]; the second one concerns corrosion processes, and includes the results of laboratory experiments. [18]

As regards the processes, only very brief indications will be given here, for more details and a fuller bibliography, the reader is referred to the previous paper by the author [18]. It seems that the forms observed are the result of a number of processes, and not only of solution or biological action. Of particular importance is alternate wetting and drying in the spray zone and in the upper part of the intertidal zone, especially in warm countries: these alternations bring about a disaggregation of the rock, especially when it is heterogenous (for example,

calcarenites including many small quartz particles). Destruction by microscopic algae is also certain. Solution by sea-water seems highly probable, although Ranson denies it [17]. Strong motion of water related to the surf plays a part [19]. In addition corrosion is more efficient with salt water than with fresh water, but salt is not at all necessary, for typical forms are exposed on lake shores, *e.g.* around Loughs Erne and Eske, Ireland.

In previous papers concerning Western Europe, it has been shown that in the British Isles, the zonation in coastal limestones is as follows: in the spray zone, very small honeycombed corrugations, much less than one inch in size, covering the rock, or only its most exposed parts; at a lower level, very jagged pinnacles or *lapiés* with sharp sides, between three inches and one foot in size, extending down to low-water mark; at both levels, shallow, flat-bottomed ponds with overhanging sides, the highest ones being supplied with sea-water by storm waves. On the contrary, in South Portugal (Vila Nova de Milfontes near Cape Sines), the zonation in Pleistocene eolian calcarenites is the same as in Morocco: in the spray and storm-wave zone, a pitted topography with jagged *lapiés* (which thus occur at a higher level than in the British Isles) and intervening shallow ponds with overhanging sides; in the high neap tide and mean sea-level zone, very shallow ponds with perfectly flat bottoms, bounded by extremely continuous, narrow, low, meandering rims, in a festoon-like configuration. The whole zone, which was termed *plate-forme à vasques* in French, is gently sloping towards the sea, each pond lying at a slightly lower level than the preceding one, so that a characteristically terraced pattern appears [20]; farther down, this platform is much dissected by other ponds, much deeper (one to two feet), again with overhanging sides and extending down to low spring tides; it ends in a low spring-tide cliff. The limit between the pitted zone and the pond-platform zone consists of an overhanging visor; but this visor is not so large as in tropical seas, from which the same zonation has been also reported (Oahu, Madagascar, Red Sea etc). The *plate-forme à vasques* exists in Portugal as far North as Cape Razo near Lisbon, where the forms are, however, less typical; farther North in Portugal, the British zonation was found in limestones at Nazaré and Cape Mondego.

But the kind of zonation that occurs in the intervening countries, that is, around the Bay of Biscay, remained unknown. Other researches were carried out in order to fill the gap, and the purpose of this paper is to describe the results. Investigations were made of the calcareous shores of North Spain, of Aunis, Saintonge and Poitou (France), and of West Brittany. Long stretches of coast were not looked at because they include no limestone outcrops.

The coastal regions of the Bay of Biscay have a temperate oceanic climate, even in the south: nowhere is there a dry season in summer, unlike the Portuguese coast. However, the air temperature is a little higher in the south-eastern corner of the Bay than on its other coasts: the mean annual temperature lies between 11° and 13° C along West and South Brittany, Vendée, Aunis and Saintonge, nor does it reach 14° C in North Galicia and West Asturias; but, east of Santander in Spain, and at Biarritz in French Pays Basque, values exceeding 14° C

are recorded [21, 22, 23]. The same fact is even more conspicuous in the distribution of surface temperatures of sea-water [24]: the mean annual temperature is lower off West Brittany, along Aunis and Saintonge, and off Galicia, than it is along East Asturias and in the south-eastern corner of the Bay, where it exceeds 16° C and even 17° C (Fig. 1). According to the above quoted German atlas, this distribution exists throughout the year, the most contrasted situation occurring in summer.

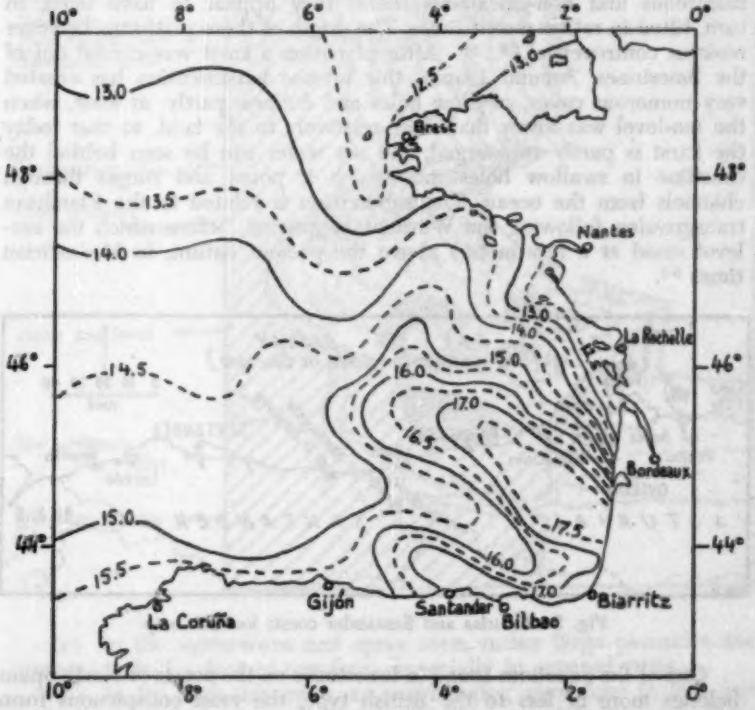


Fig. 1 Mean annual sea surface temperature (C°) in the Bay of Biscay, according to *Oberkommando der Kriegsmarine Atlas*, 1941.

The distribution of sea and air temperature has consequences on coastal biology: the inner, south-eastern part of Biscay has a distinctly warmer marine flora and fauna than both Galicia and Brittany, although, as Fischer-Piette [25] pointed out, the limits of species in North Spain have been subject to variations in recent years.

ASTURIAS AND SANTANDER COASTS (Fig. 2)

A good general description of the Palaeozoic strata in Asturias is found in Barrois [26] and the reader will find more detail about the most

interesting calcareous coast in this province in the Spanish geological map of Llanes and its explanatory memoir [27]. The limestones belong principally to the Carboniferous and the Cretaceous periods, with extensive outcrops in the Llanes and Pendueles district, but there are limestones of other systems, particularly of Devonian age between Avilés and Gijón, and of Cambrian in Aguilar cove near Pravia. Other limestones occur between Santander and Bilbao. Conspicuous high coastal platforms, the so-called *rasas*, have bevelled the highly folded calcareous and non-calcareous rocks; they appear to have been, in turn, tilted in rather recent times. The origin of these platforms however remains controversial [28, 29]. After planation a karst was carved out of the limestones. Around Llanes, this intense karstification has created very numerous caves, swallow holes and dolines, partly, at least, when the sea-level was lower than now relatively to the land, so that today the karst is partly submerged: the sea water can be seen behind the coastline in swallow holes into which it pours and surges through channels from the ocean. The submersion is related to the Flandrian transgression following the Würmian regression, before which the sea-level stood at a few meters above the present datum, in Monastirian times [30].

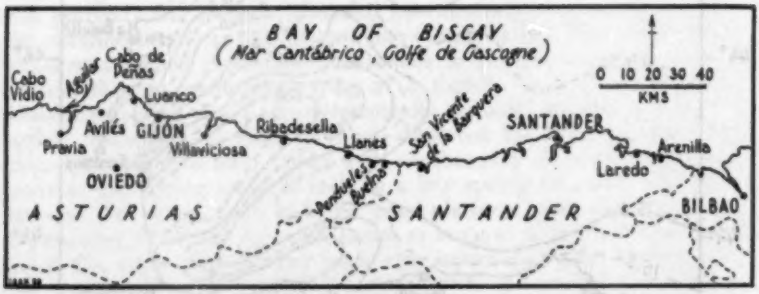


Fig. 2 Asturias and Santander coast; location map.

One of the zonations found in limestones on the coasts of North Spain belongs more or less to the British type, the most conspicuous form being sharp *lapiés* extending down to low-water mark. Such is the case in the Devonian limestones on both sides of Penas promontory (north-west of Luanco, and south-west of Cape Penas). But it is important to notice that the *lapiés*, honeycombed patterns and small ponds with overhangs, are rather ill-defined or absent in sheltered places: they require heavy surf for full development, and so it is too in the Cambrian strata of Aguilar cove. The same relation is found in Western Brittany. The *lapiés* are generally small, only two to four inches in depth, but sometimes larger ones occur (*e.g.* in Infracretaceous rocks north of Llanes). As on many other shores, the typical *lapiés* disappear beneath the lowest water mark. Near Buelnes, typical corrosions with small overhangs were seen around freshwater ponds slightly behind the coastline, showing that, as around Loughs Erne and Eske (Ireland) salt is not necessary.

Another much more original zonation is displayed in the eastern part of the North Spanish coast, particularly in the Llanes-Pendueles region (East Asturias), and at Arenilla (Río Aguera, between Santander and Bilbao). The succession of forms from above to below is as follows (Fig. 3):—

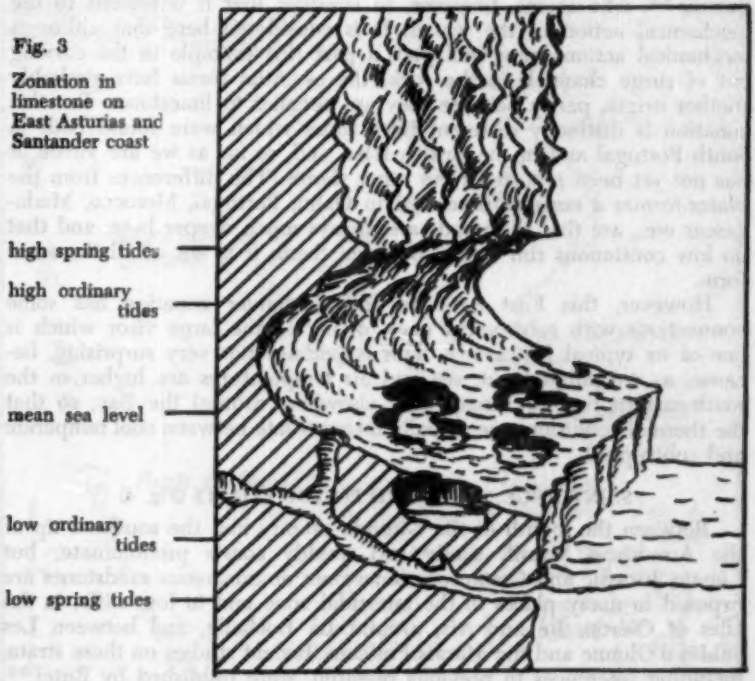


Fig. 3
Zonation in limestone on East Asturias and Santander coast

(a) in the storm-wave and spray zone, rather large pinnacles and grooves (a half a foot to one foot), especially in exposed parts.

(b) in the high-tide zone, an overhanging visor four to five feet wide, into which are carved other *lapiés*. This visor fails to occur where the strata show a steep dip slope towards the sea (at Llanes in Cretaceous rocks).

(c) beneath the visor, and extending down to ordinary low neap tides, a platform, five to fifteen feet wide, into which are cut ponds with overhangs up to three inches wide. The platform slopes steeply towards the sea, at an angle which varies between 8° and 50° and averages 15–20°. It is constantly wetted by the swash at half tide, and is often covered with *Bifurcaria tuberculata or Tenarea tortuosa* (alias *Lithophyllum tortuosum);* on the bottom of the ponds, *Lithophyllum incrustans* and sea-urchin colonies are found (Pl. 1c).

(d) the platform ends in an extremely steep or vertical slope, the upper part of which is well exposed at low spring tides; more or less rounded grooves appear in it. In many parts of the coast (*e.g.* Buelna,

Arenilla), surge channels and caverns start from this outer slope and extend under the platform and sometimes farther into the rock for several metres, often ending in blow-holes.

The same morphology is apparent either in cliffs or in stacks standing in front of them. Some of its features were already noticed by Barrois [26], who seems, however, to consider that it is related to the mechanical action of the waves. It is considered here that although mechanical actions may well play a part (for example in the carving out of surge channels in the rock) the essential forms have probably another origin, partly because they are peculiar to limestones. But this zonation is distinctly different from those which were found both in South Portugal and in the British Isles, and, so far as we are aware, it has not yet been reported from other shores. The differences from the *plates-formes à vasques* described in Oahu, Portugal, Morocco, Madagascar etc., are that the ponds are always much deeper here, and that no low continuous rim occurs between them: it is not at all the same form.

However, this East Asturian and Santander zonation has some connections with subtropical ones, owing to the large visor which is one of its typical features [31]. This is perhaps not very surprising, because, as we pointed out, sea and air temperatures are higher in the south-eastern part of Biscay than elsewhere around the Bay, so that the thermal conditions are actually intermediate between cool temperate and subtropical.

SAINTOINGE, AUNIS AND POITOU COASTS (Fig. 4)

Between the mouth of the Gironde estuary and the southern tip of the Armorican Massif, sandy and muddy coasts predominate; but Liassic, Jurassic and Cretaceous limestones or calcareous sandstones are exposed in many places in the intertidal zone and in low cliffs, in the Isles of Oléron, Ré and Aix, around La Rochelle, and between Les Sables d'Olonne and the Marais Poitevin. Recent studies on these strata, including references to previous research, were published by Butel [32], Butel and Ters [33], Waterlot and Polvêche [34]; the contours appear on the general French geological map of La Rochelle (1 : 320,000) and on the more detailed 1 : 80,000 maps of Les Sables d'Olonne, La Tour de Chassiron and La Rochelle. A good morphological description of the coast is included in Papy's work [35] and also in that of Bourcart [36].

A very important point is that, in this region, the limestones are not nearly so massive and hard as they are in North Spain. Many of them are marly, and, very frequently, they are thinly bedded, fissured, and easily worn back into cliffs which often display a stepped or crumbling profile. A great number of small blocks and plates are constantly falling from the cliffs down to the shore. The mechanical action of the sea seems to be efficiently helped by frost splitting during the cold winters; moreover, frost action during the Ice Age greatly contributed to the splitting of these thinly bedded limestones into plates and to the reduction of their massivity.

As a consequence of this, it was usually not possible to find true corrosion forms (that is, other than those related to mechanical erosion) *in the cliffs* of this region, although many exposures were examined.

Fig. 4 Saintoigne, Aunis and Poitou coast; location map.

The rate of retreat of the cliffs is high enough to prevent such forms being initiated. The struggle between corrosion and mechanical destruction is easily won by the latter, as it is, for example, at Pointe de l'Aiguille, near Fouras in front of the Isle of Aix; at Pointe du Rocher, Pointe de Châtelaillon and Angoulins, between Fouras and La Rochelle; at Jard, South Vendée, etc. In a single occurrence, between Le Veillon and Bourgenai in South Vendée, some micro-corrosive forms were occasionally observed in Liassic limestones (small corrugations, and scattered flat-bottomed ponds bounded by micro-indentations, in the high-tide zone).

Yet, at a lower level, between half tide and ordinary low tide, biological corrosion is widespread and sometimes most spectacular, especially in the Isles of Ré and Oléron. At Pointe des Baleines and Pointe de Chassiron, *Pholades* burrowings are innumerable; limpets also cut their dwellings into the rock. Although the general features of the foreshore at Pointe de Chassiron are related to rock bedding, there is no doubt that biological boring plays a considerable part in erosion. In places such as La Brée and La Gautrie, Oléron, and Les Grenettes, Ré, superficial micro-honeycombings by *Clionae* (small boring sponges) are the most characteristic feature. At Les Grenettes, these burrowings by *Clionae* result in small ponds (a few inches to one foot wide) of a special kind, the margins of which are being progressively eaten back by the dense colonies of sponges which live on them, so that the ponds are slowly enlarged (Pl. 1a).

Perhaps Les Grenettes ponds might throw some light on the process of formation of the *vasques* of subtropical and tropical countries, the exact origin of which so far remains obscure. Here, the enlargement of the ponds is clearly related to the *Clionae*, which settle especially around the ponds, at the base of the residual rocks forming the rims, which remains wet at low tide. The intervening rims are thick at the beginning of the evolution, but, as they are burrowed, they progressively become thinner, and finally a pattern appears which bears some resemblances to a true *plate-forme à vasques* with narrow rims, although the rims are much less regular and continuous here. It is suggested that the origin is perhaps of the same kind, the nature of the rock being here particularly favourable to boring colonies, and allowing a development of forms more usually and more typically found in warmer seas. A revision of the true *vasques* on warmer shores could be undertaken with these suggestions in mind.

But the biological borings do not create true *lapiés* in this district, and this popular feature of the calcareous shores was not found here, except between Jard and Pointe du Payré, South Vendée. There occur, at half-tide level, small overhanging *lapiés*, up to half-a-foot high, not at all sharp, with intervening flat-bottomed ponds which practically disappear below ordinary low tides. Thus, as has been pointed out in other papers, the pinnacles of the *lapié* type are characteristic of the intertidal and spray zones, and do not extend down to constantly submerged levels.

Summarising these observations, we might say that, if adequate lithological conditions were found on Poitou, Aunis and Saintonge coasts, the zonation of corrosion forms in limestones would probably belong to the British type, because in rare places where the rocks are favourable, elements of such a zonation are to be seen. But, generally speaking, the cliffs are retreating rapidly and the time is insufficient for elaboration; on the foreshore, *lapiés*, probably of composite origin, are occasionally found, but, in most places, one of the corrosion processes, the biological borings by *Pholades*, *Clionae* and *Patellae*, prevents the other processes from having a noticeable effect, perhaps because these rather soft and often marly limestones are particularly attractive for such a fauna. The relatively sheltered conditions along this coasts may

be another reason for the rare occurrence of usual corrosion forms (compare with the Asturian and Breton coasts).

WEST BRITTANY COAST

Taken as a whole, the Armorican Massif is not calcareous; but the Palaeozoic strata of the *synclinorium médian* include, on the shores of the Rade de Brest and Crozon Peninsula, numerous small outcroppings of limestones (Fig. 5). As regards to stratigraphy and palaeontology, these sections have been very carefully investigated and described by Collin [37], Kerforne [38], Lucas [39] and Renaud [40], and full references to stratigraphic descriptions will be found in the bibliography of this paper. The Rade de Brest and Crozon limestones belong principally to the Coblenzian or Siegenian periods; sometimes (Porzguen, Traouliors, and between Ile Longue and Quelern) to Givetian or Couvinian, and (Lostmarc'h and Rosan) to Upper Ordovician. All these sections were examined in order to discover whether typical corrosion forms are represented.

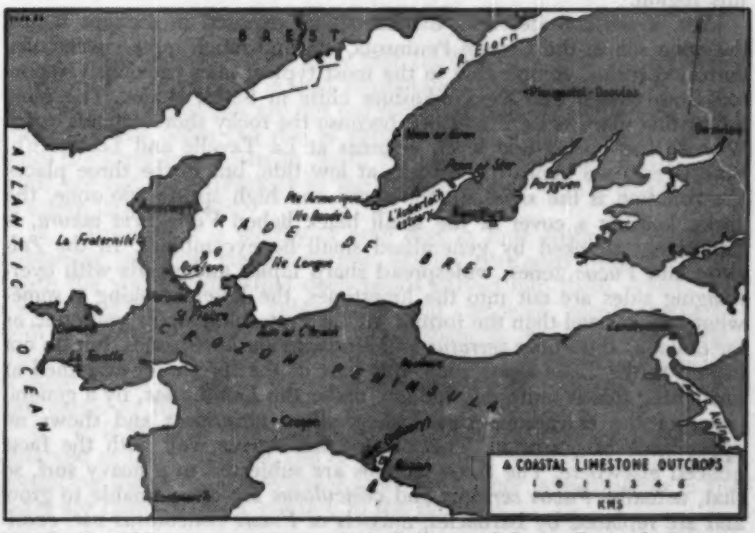


Fig. 5 Coastal limestone outcrops in Rade de Brest and Crozon Peninsula, Brittany.

In the Rade de Brest, where the waves are generally very gentle, owing to the sheltered position and the short fetches, the corrosion forms are, in most places, either rather insignificant or completely absent. None of them were found at Ilien ar Guen, Run ar C'hrank, Poulmic, Landevennec, Persuel, Rostellec (the two last places between Ile Longue and Quelern), except burrowings by *Pholades* and *Clionae* in calcareous pebbles which are not included in the solid rock. Some scattered forms appear in other places: in the north-western part of Saint Fiacre beach, ill-shaped, small *lapiés* two to four inches in size,

and a flat-bottomed pond with small overhangs; at Ponscorff, 100 yards to the north of disused lime kilns, some smooth grooves about three-quarters of a foot in size, which might be considered as the beginning of *lapié* evolution; at Traouliors and Porzguen, scattered honeycombed patterns in the cliff, up to three inches in depth; at l'Auberlac'h, stretches of ponds with overhangs, and of minor corrugations; in the inner part of l'Auberlac'h estuary, (Penn ar Ster), flutings about a third of an inch apart, and some corrugations. All these features occur in the high-tide and spray zones.

The only places in Rade de Brest where corrosion forms in limestones are rather well shaped, lie on both sides of Pointe Armorique. Along its southern side (eastern headland of the cove which is in the east of the old fortress) appear honeycombed corrugations and typical *lapiés* half-a-foot in size, in the *Ascophyllum nodosum* zone (high neap tides). At Porz Meur, on the northern side of Pointe Armorique, other *lapiés* are seen in limestones in the north-east of the pier (high spring-tide and spray zones). It is noteworthy that Pointe Armorique faces west and south-west, that is, athwart the prevailing wind direction in this region.

Yet, if we consider now the limestones exposed in sections facing the open sea in the Crozon Peninsula, we find much more spectacular corrosion forms, comparable to the most typical ones previously reported from Gower and Pembrokeshire cliffs in South Wales. The most interesting place is La Fraternité, because the rocky shore extends down beneath low spring-tide level, whereas at La Tavelle and Lostmarc'h, sand is exposed beneath the rocks at low tide; but in the three places the zonation is the same. In the spray and high spring-tide zone, the rocks, bearing a cover of the small black lichen *Verrucaria maura*, is intensively attacked by generalised small honeycombings. In the *Pelvetia* and *Fucus* zones, widespread sharp *lapiés* and ponds with overhanging sides are cut into the limestones, the latter reaching a somewhat higher level than the former. At La Fraternité, *lapiés* are found as far down as the *Fucus serratus* and *Himanthalia lorea* zones, but do not extend to the *Laminariae* zone: this part of the foreshore, examined at low spring tide is uniformly hidden, under the *Laminariae*, by a general cover of the calcareous alga *Lithophyllum incrustans* and shows no appearance of corrosion. This observation agrees well with the facts noticed elsewhere. The three sections are subjected to a heavy surf, so that, actually, *Fucus serratus* and *vesiculosus* are often unable to grow and are replaced by barnacles, mussels or *Fucus vesiculosus var. evesiculosus*, that is, the small erect *Fucus*. Another point is that in Lostmarc'h, La Tavelle and La Fraternité, the Ordovician and Devonian limestones are hard and massive, thus efficiently withstanding mechanical erosion: this condition is exactly the contrary of what is found in Poitou, Aunis and Saintonge, where *lapiés* are very poorly represented, so that the surf certainly operates *indirectly* when creating sharp pinnacles: it multiplies the wetting-drying alternations, it allows more active biochemical borings, and it makes solution easier through water motion (Pls. 1b and d).

A fourth section in limestones along the outer coast of Crozon peninsula is found at Rosan, which is an islet in the mouth of a small

estuary. Small honeycombed corrugations, and, lower, some *lapiés*, occur here too, facing south-west, but they are not so well-developed as in the above quoted exposures. The reason is that this islet is more sheltered, owing to its estuarine location. At present, it is actually very sheltered, because sand dunes are enclosing the estuary, but these dunes are probably not very old, so that, before they were built up, a moderate surf was acting on the south-west coast of the islet, and it is suggested that the corrosion forms were initiated at that time.

Probably the principal interest of the West Brittany observations is to demonstrate with great accuracy the influence of exposure to surf on the development of corrosion forms. The opposition between poor development along the sheltered coasts of the Rade, and the perfect zonations of British type on the outer coasts, is particularly striking. This is particularly true when the contrast exists in the same rocks, as in the case at La Fraternité and Ponscorff (Coblenzian limestones belonging to the same fold, and outcropping on the shore on both sides of Crozon Peninsula. See geological map in Renaud, p. 118) [40].

CONCLUSIONS

1. These investigations show that the British type of coastal corrosion forms in limestones is well represented around the Bay of Biscay, provided the limestones are not too soft nor too desaggregated by cryoturbation, and when the surf is strong enough. This is not surprising, since the same type exists in North Portugal, where the thermal conditions are not very different in the Bay of Biscay as a whole, and in Western British waters.

2. However, it is worthy of note that in East Asturias and in the Santander province, curious narrow, sloping platforms were found beneath the visors with rather deep ponds carved into them, which bear some resemblances to subtropical and tropical zonations, along with differences which do not allow them to be classified among the *plates-formes à vasques*. It is suggested that this particular zonation is more or less related to the thermal maximum occuring in the South-east corner of Biscay.

3. It is possible that the process of pond enlargement which was observed at Les Grenettes, Isle of Ré, has some connections with those producing the *vasques* in warmer seas; but further investigations in the latter are required for a solution to the problem.

The writer is indebted to the French National Centre for Scientific Research, which granted a fund for investigations in Spain; to Professors Solé Sabaris, S. Llobet and Llopis Llado, who gave help in the same country; and to Dr A. Dizerbo, who accompanied the writer in Spain and in Brittany, and whose assistance and knowledge in intertidal biology were very useful.

[1] Corbet, J. Les Karsts du Nord-Ouest de l'Europe. *Inst. des Et. Rhodaniennes de l'Univ. de Lyon, Mém. et Docum.*, 1957, XII, p.541.

[2] Wentworth, C. K. Marine bench-forming processes. II : solution benching. *J. of Geomorphology*, 1939, II, pp. 3-25.

[3] Macfadyen, W. A. The undercutting of coral reef limestone on the coasts of some islands in the Red Sea. *Geogr. J.*, 1930, LXXV, pp.26-34.

[4] Guilcher, A. Formes de décomposition chimique dans la zone des embruns et des marées sur les côtes britanniques et bretonnes. *Vol. Jubil. Cinquantième Annic. Labor. Géogr.* Rennes, 1952, pp.167-181.

[5] Guilcher, A. Essai sur la zonation et la distribution des formes littorales de dissolution de calcaire. *Ann. de Géogr.*, 1952, LXII, pp.161-179.

[6] Common, R. Les formes littorales dans les calcaires en Northumberland septentrional. *Ann. de Géogr.*, 1955, LXIV, pp.126-128.

[7] Givago, A. V. On solution and abrasion forms in limestones of the West coast of Crimea. *Bull. Geogr. Soc. U.S.S.R.*, 1950, vol. 82, pp.615-618 (*in Russian*).

[8] Guilcher, A. Morphologie littorale du calcaire en Méditerranée occidentale (Catalogne et environs d'Alger). *Bull. Ass. Géogr. Français*, March-April 1954, No. 241-242, pp.50-58.

[9] Guilcher, A. et F. Joly. Recherches sur la morphologie de la côte atlantique du Maroc. *Trav. Inst. Scient. Chérifien*, Tanger, 1954, p.140.

[10] Guilcher, A. Formes de corrosion littorale du calcaire sur les côtes du Portugal. *Tijd. Kon. Nederl. Aardr. Gen.*, 1957, LXXIV, pp.263-269.

[11] Ginsburg, R. N. Intertidal erosion on the Florida keys. *Bull. Marine Sc. Gulf and Carribean*, 1953, III (1), pp.55-69.

[12] Taillefer, F. Les rivages des Bermudes et les formes littorales de dissolution du calcaire. *Cahiers de Géogr. de Québec*, n. ser., April 1957, No. 2, pp.115-137.

[13] Guilcher, A. Géomorphologie de l'extrémité septentrionale du banc Farsan (Mer Rouge). *Ann Inst. Océanogr.* 1955, XXX, pp.55-100.

[14] Fairbridge, R. W. Notes on the geomorphology of the Pelsart group of the Houtman's Abrolhos Islands. *J. Roy. Soc. Western Australia*, 1946-47, XXXIII, pp.1-43.

[15] Guilcher, A. Etude géomorphologique des récifs coralliens du Nord-Ouest de Madagascar. *Ann. Inst. Océanogr.*, 1956, XXXIII, pp.65-136

[16] Battistini, R. La zonation de l'estran dans les grès littoraux au Cap Mendevitse près de Morombé (côte SW de Madagascar). *Mém. Inst. Scientif. Madagascar*, série D, 1957, VIII, pp.183-193.

[17] Ranson, G. Observations sur l'agent essentiel de dissolution du calcaire.... dans l'archipel des Tuamotu. *C.R. Ac. Sci. Paris*. February 1955, vol. 240, pp.806-808 and 1007-1009.

[18] Guilcher, A., et P. Pont. Etude expérimentale de la corrosion littorale des calcaires. *Bull. Ass. Géogr. Français*. March-April 1957, No. 265-266, pp.48-62.

[19] Kaye, C. A. The effect of solvent motion on limestone solution. *J. of Geol.*, 1957, LXV, pp.35-46.

[20] It is absolutely necessary not to confuse what we call *vasques* in French, with other different kinds of ponds, for example those bounded by small overhangs which are not narrow rims, and commonly occur in temperate Atlantic countries. Such a confusion has unfortunately been made by Corbel (phots. 76, 77 and 78) [1]. True *vasques* forming a terraced, festoon-like pattern, may be seen in Wentworth, p.13 [2]; Guilcher and Joly (phot. 17, 18, 22)) [9]; Guilcher (pl. VIII A, phot. B) [5]; Battistini (pl. X A, XII B, XIII A) [16].

[21] Hann, J. *Handbuch der Klimatologie*. Vol. III, 2nd part, Stuttgart, 1911.

[22] Sanson, J. Recueil de données statistiques relatives à la climatologie de la France. *Mémorial Météorol. Nationale*, No. 30, Paris, 1945.

[23] Teran, M. de. *Geografia fisica de Espana y Portugal*, Vol. 2, Barcelona, 1954.

[24] *Oberkommando der Kriegsmarine* (L. Möller). Temperatur, Salzgehalt, Dichte und Strömungen an der Oberfläche und in den Tiefen der Biskayabucht (Atlas). Institut für Mooresk., Berlin, 1941, 128 maps. This atlas, prepared by the Institute of Oceanography in Berlin and published by the German Navy during the World War II for official use, is based on a compilation of all hydrological data available in 1941 for the Bay of Biscay.

[25] Fischer-Piette, E. Répartition, le long des côtes septentrionales de l'Espagne, des principales espèces peuplant les rochers intercotidaux. *Ann. Inst.Océanogr.*, 1955 XXXI (2), pp.38-124 (*and C.R. Ac. Sci. Paris*, 25 July 1955, vol. 241, pp.447-449).

[26] Barrois, Ch. Recherches sur les terrains anciens des Asturies et de la Galice. *Mém. Soc. Géol. du Nord*, 1882, II (I), p.630.

[27] *Mapa Geologico de Espana*, Hoja No. 32, Llanes. Madrid, 1950, p.109 and map (1:50,000).

[28] Hernandez-Pacheco, F. Las rasas litorales de la costa cantábrica en su segmento asturiano. *XVIth Intern. Géogr. Congr.*, Lisbon, 1949, II, pp.29-86.

[29] Llopis Llado, N. Los depósitos de la costa cantábrica entre los Cabos Busto y Vidio (Asturias). *Speleon*, 1956, VI (4), pp.333-347.

[30] Guilcher, A. La plage ancienne de la France (Asturies). *C.R. Ac. Sci. Paris*, 28 November 1955, vol. 241, pp.1603-1605.

[31] Corbel, J. Sols polygonaux et terrasses marines au Spitzberg. *Rev. Géogr. de Lyon*, 1954, XXIX, pp.1-28. Visors are also represented, it is true, along calcareous shores in the Arctic, namely in Spitzberg, see Corbel, J; but, under those latitudes, frost action probably plays a very large part in their shaping.

[32] Butel, P. Revision de la feuille des Sables d'Olonne. Le Lias et le Jurassique sur le littoral. *Bull. Serv. Carte Géol. France*, 1951, XLIX (232), pp.97-107.

-.- Les formations d'âge secondaire du Sud de la Vendée entre le massif ancien et l'Océan. *Ibid.*, 1953, LI (239), pp.301-333.

-.- Notes complémentaires sur quelques affleurements de Vendée méridionale. *Ibid.* 1955, LIII (246), pp.185-192.

[33] Butel, P., and M. Ters. Géologie de l'Ile de Ré. *Ibid.*, 1952, XLIX (234), pp.539-576.

[34] Waterlot, G., et J. Polveche. Structure géologique de l'Aunis. *Bull. Serv. Carte Géol. France*. 1953, LI (239), pp.99-105.

[35] Papy, L. *Les aspects naturels de la côte atlantique de la Loire à Gironde*. Bordeaux, 1941, p.302.

[36] Bourcart, J. Note sur l'érosion marine de la côte entre la Tranche (Vendée) et l'Ile Madame (Charente Maritime). *Bull. Comité d'Océanogr. et d'Et. des Côtes*, 1953, V, pp.396-401.

[37] Collin, L. *Etude de la région dévonienne occidentale du Finistère*. Thesis Paris, Brest, 1912, pp.470. *Idem* (Limestones along the Rade de Brest and Crozon Peninsula coasts). Ilien ar Guen: *Bull. Soc. Géol. et Minéralog. de Bretagne*, 1925, VI, (2-4), pp.265 and 269; Ile Ronde and Pointe Armorique: *Ibid.*, 1924, V, (1), pp.21-31: Poulmic: *Ibid.*, 1924, V (2-4), pp.217-219; Run ar C'hrank:*Ibid.*, 1922, III (3), pp.250-251; 1924, V (2-4), pp.216-217; 1925, VI (2-4), p.227; La Tavelle: *Ibid.*, 1924, V (2-4) pp.216 and 220; La Fraternité: *Ibid.*, 1924, V (2-4), pp.209-212 and 220; Ponscorff: *Ibid.*, 1926, VII, (2-4), pp.208-215; Landevennec: *Ibid.*, 1926, VII (1-2), pp.29-32; L'Auberlac'h estuary: *Ibid.*, 1927, VIII, p.10, 14 and 19; Between Ile Longue and Quelern: *Ibid.*, 1926, VII, (1-2), pp.37-45, and 1924, V (2-4), pp.212-215.

[38] Kerforne, F. *Etude de la région silurique occidentale de la presqu'île de Crozon*. Rennes, 1901, pp.234. (Limestones: La Tavelle: pp.23 and 38. - Lostmarc'h: pp.46, 60, 89 and general map. - Rosan: pp.87-90 and general map.

[39] Lucas, G. Contribution à l'étude du Silurien de la Presqu'île de Crozon. *Bull. Soc. Géol. et Minéralog. de Bretagne*, 1938, pp.95-126 (Rosan limestones: see map).

[40] Renaud, A. Le Dévonien du synclinorium médian Brest-Laval. Stratigraphie. *Mém. Soc. Géol. et Minéralog. de Bretagne*, Rennes, 1942, p.184 (limestones: Porzguen: p.150. - Ponscorff, La Fraternité, Run ar C'hrank, etc.: p.11, map).

THE DELIMITATION OF SOME URBAN LANDSCAPE FEATURES IN BELFAST

EMRYS JONES

THE urban geographer shares with all other geographers the problem of delimiting regions. Sharply contrasting quantitative differences in adjacent sectors of towns are rare, the homogeneous region almost non-existent. For the most part our categories are abstract concepts aud our lines arbitrary: but they are nevertheless necessary to facilitate description and to test hypotheses.

The major difficulty is that of defining the delimiting line. This is especially so if one line has to serve as a limit for several characteristics within one region. A simpler approach to the definition of such complex regions is to break down the area to be subdivided in terms of several characteristics in the complex. The delimitation of the separate characteristics may be comparatively straightforward, for indices can be selected which are easy to define and delimit. When these are superimposed they will give the more complex regions which will serve to describe, and in part explain, the differences in the landscape.

Before building up such regions for any city it is necessary to decide which indices can be used, which characteristics can best serve the purpose. In the following example the description will be limited to the purely physical *residential* urban landscape. To simplify the problem further, three indices only will be used to differentiate regions, and for each index the city will be broken down into two categories only – a characteristic will be either present or absent.

In Belfast, the city taken to demonstrate this method of delimiting regions, it seemed that three criteria contributed most to the physical make-up of the landscape outside the centre: 1. age; 2. whether retail functions were part of the landscape or not; and 3. whether residential areas were of terrace housing or of the detached or semi-detached type. Each was broken down into two categories as follows: –

AGE	A	Old, *i.e.* pre-1896 buildings (see p. 152).
	a	New, *i.e.* post-1896 buildings.
FUNCTION	B	Areas characterised by retail shopping.
	b	Areas with no retail shopping.
HOUSING	C	Terrace housing.
	c	Detached and semi-detached housing.

Theoretically these could give, in combination, eight residential landscape regions or types of region, as follows: —

1. ABC Old regions with shops : terraced housing.
2. aBC New regions with shops : terraced housing.
3. ABc Old regions with shops : detached housing.
4. aBc New regions with shops : detached housing.
5. AbC Old regions with no shops : terraced housing.
6. abC New regions with no shops : terraced housing.
7. Abc Old regions with no shops : detached housing.
8. abc New regions with no shops : detached housing.

		Age A	Age a	
Housing	C	ABC	aBC	B
	c	ABc	aBc	
Housing	C	AbC	abC	b
	c	Abc	abc	

Function

Each of these indices was mapped separately, but when they were superimposed the possible combinations were revealed areally. Some of the possible combinations do not in fact exist. For the rest the distribution of each type of region is shown for the city as a whole. Where-ever similar combinations of characteristics occur it can be assumed that the physical urban landscape is similar. Moreover the overall picture of regional differentiation gives a pattern which can be compared with those of other towns. Some conclusions will be drawn from the application of this method to the delimitation of urban landscape regions in Belfast.

From the criteria already mentioned it will be clear that our regional delimitation involves the residential areas of the city only and expressly excludes: (a). the city centre; and (b). the dock-ship-building sector at the head of the lough, both distinctive non-residential landscapes. The line dividing housing from dockland is clear cut, the line delimiting the city centre is that of the outward limit of blocks in which the main functions are non-residential.

For the remainder the first criterion is age (Fig. 1a). To maintain the simplicity of expressing each criterion in terms of two categories, buildings must be classed rather arbitrarily as old or new. Obviously these are relative terms which would vary considerably when applied to different towns. Belfast is built almost entirely of brick. It is well-built — in the sense of being solidly built at least. It is mainly Victorian in age. [1] Practically all the houses which were built after 1857 are still in use, in addition to 6,500 houses built before that date and representing a third of the town as it was in mid-nineteenth century. [2] Improvements in the building of industrial workers' houses, as well as changes in style of larger residences, were extremely gradual from the beginning of the Victorian era to well into the twentieth century. A recognition of the smaller changes would involve very many categories

which would also differ for industrial and purely residential areas. From the point of view of age alone the median lies very near the turn of the century. The precise date, 1896, was determined as is so often the case, by the availability of map evidence. If this dividing line is accepted, it is an easy task to divide the city into two categories along the limit of housing in 1896. Inevitably there are some houses outside this line which were built before 1896; they are the former larger houses which once ringed the town. Many of them have been replaced, converted into modern dwellings, or have changed their function and become schools, offices, or even community centres for new estates of houses built in their spacious gardens.

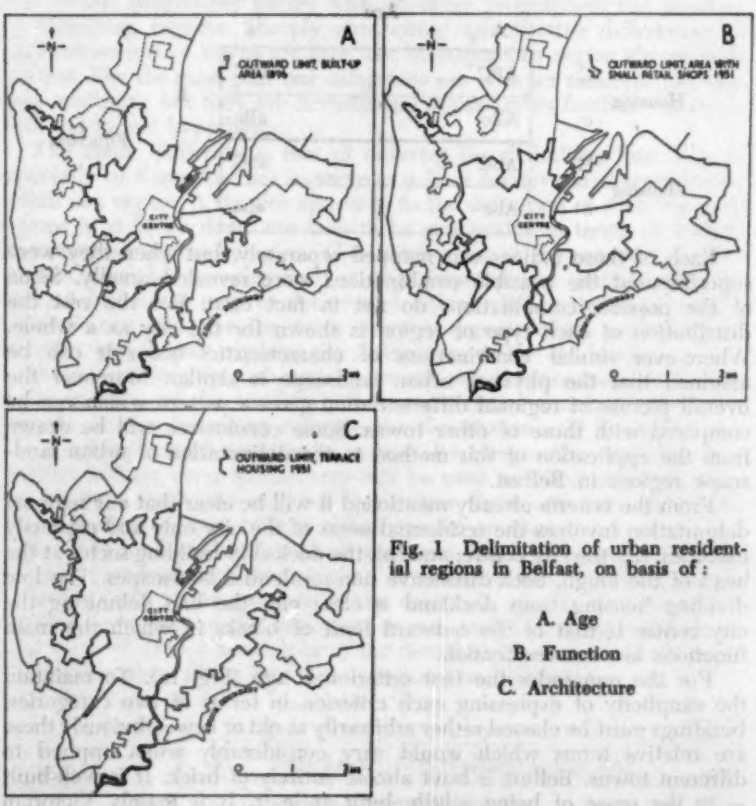


Fig. 1 Delimitation of urban residential regions in Belfast, on basis of:

A. Age

B. Function

C. Architecture

The second criterion is concerned with function (Fig. 1b). The delimiting line chosen is the outward limit of those areas in which retail shopping is an integral part of the landscape. Shopping which extends along the main roads out of the city has been excluded: there is a difference in the kind of residential neighbourhood whose needs are served by shops along the nearest traffic artery, and those neighbourhoods in which shopping is also found scattered throughout the area.

The fact that the city can, on this basis, be divided into two parts, an inner and an outer zone, emphasises the exclusively residential nature of the outskirts. The line is drawn where the corner store and the parlour shop as an integral part of the neighbourhood are no longer found.

The third criterion is one of the most obvious contrasts in residential areas: whether housing is terraced or not (Fig. 1c). Again, if housing were being studied separately it would be possible to subdivide residential areas on a much more complex and comprehensive basis, taking size and density, for example, into consideration. But it is necessary to confine ourselves to two categories, and these in some degree reflect density as well. Again the delimitation is considerably simplified by the fact that the detached housing, with very few exceptions, is found in a peripheral zone, around a central area where terrace housing completely dominates the scene. Occasionally, expanding suburbia has engulfed a small group of terraced houses which were once a separate village, but this occurs less often than one would expect; few of the old villas, which were themselves engulfed in the nineteenth-century expansion of terrace housing, have survived.

Although their combined use produces a complex enough map, three criteria alone are few on which to base differentiation of an urban landscape. One obvious other one is the presence or absence of industry, and it will be shown that this is closely correlated with the criteria chosen. Apart from simply noting the sites of various industries its mapping, however, would be difficult. How far does the influence of a factory extend in affecting the desirability of an area for residence, for example? Is it within the shadow of the factory, or is it under its smoke pall, or, as with the gas works, within the range – and a very extensive range it is – of its smell? Could one compare the vast engineering mills of the ship-yards with the almost apologetically unobtrusive light industries on the south-east periphery of the city? Another criterion which the geographer would look for is that of the natural landscape, and this has played its part. What is the effect of slope, of land liable to flooding, of light sandy soils as opposed to clays? Once again it would be impossible to introduce even a few of these concepts without making the map much too complicated; that is why we are restricted here to the man-made features only of the landscape, and to the residential areas in particular. Several types of residential regions are revealed in the map (Fig. 2).

Around the city centre is a very broad nearly continuous zone, in which all the criteria combine (ABC). It is a region of old terrace housing in which the corner store and the parlour shop are characteristic of the urban scene. This type of landscape is very extensive in the industrial west; in the north, where it is found in close conjunction with shipping and warehousing; and in the east on the County Down side of the river Lagan, in an area dominated by ship-building activities. It is less extensive in the south, partly restricted by the lowlying floodable Bog Meadows through which flows the Blackstaff, a tributary of the Lagan. In the south-east it is restricted by the presence of a very large park which was once the demesne of the Marquis of Donegall.

This zone is largely the product of the industrial growth of Belfast in the Victorian era. In north, south and east, where it impinges on

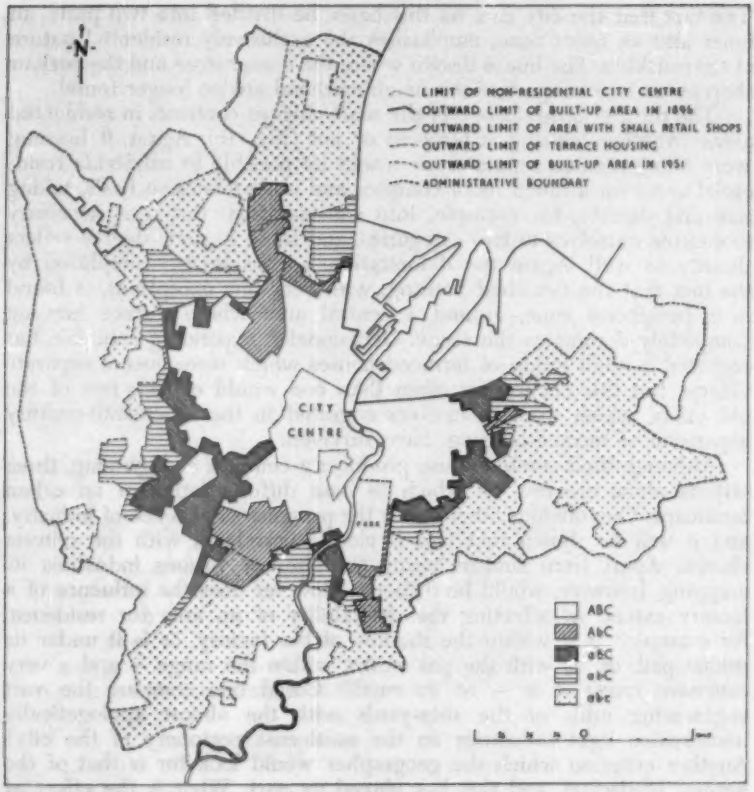


Fig. 2 Urban regions of Belfast.

ABC	....old regions, with shops	: terraced	housing
AbC	....old regions, no shops	: terraced	housing
aBC	....new regions, with shops	: terraced	housing
abC	....new regions, no shops	: terraced	housing
abc	....new regions, no shops	: detached	housing

the city centre there is a railway station, where, from the mid-century onwards, were deposited the impoverished country folk of Ulster, many of them fleeing from the famines of the eighteen-forties; these were to be the main stratum of the industrial population of the growing town.

In one other area only are the three criteria combined as in this central zone, and that is on the very outskirts of the built-up area. This is Legoniel, lying just off the main north-west route from Belfast. Legoniel is an old industrial village which the city has now all but swallowed; and apart from its somewhat rural setting it is functionally and physically comparable with the industrial sectors nearer the centre of the city.

In this first landscape region, against a setting of mills and smoke, stacks and gantries, are set the endless rows of small, identical, workers'

houses which the last century has bequeathed to this. Most of them are the products of the not too enlightened bye-laws of 1878, some of the byelaws of 1848. [3] The minimum standards which these set, both in type of streets and in type of houses, unfortunately became the accepted standard. Many of the mid-nineteenth century houses have no back access, so that although there are tiny yards the houses are, in effect, practically back-to-back; the vast majority are very small, two-storied, and single-fronted. The brick, of which they are invariably built, is relieved by a painted rim around windows and doors, and by painted window sills: in areas where Roman Catholic and Protestant populations are sharply defined this is often a partisan gesture only, but it always offers a slight relief in an otherwise unrelieved drabness. Some cobbled streets remain to remind one of the once universal method of paving side streets. Along the major roads traversing these are larger houses, sometimes with an additional attic storey, sometimes three-storied; still of brick, some have the added Victorian embellishments of bay windows, and yellow bricks make diaper patterns against the universal red. On the whole conditions are mean, cramped and crowded. Every corner has its shop, every vista has its factory, and every alley-way is a play-ground for scores of children. (See Pls 4a and b).

There are three sectors within the older part of the town which are purely residential and terraced in character (AbC). The northern sector is aligned along the Antrim Road. It approaches quite near to the city centre and occupies comparatively high ground overlooking Belfast Lough from the west. During the late eighteenth and early nineteenth centuries, when the town was entirely contained within what is now the city centre, this ridge of land led to the favoured slopes of Cave Hill, the former hunting ground of the Donegall family, but later parcelled out as many prosperous country estates. A map of 1789 shows at least a dozen of these estates on the land sloping down to the lough between Belfast and Whitehouse five miles to the north. [4] The second sector, again an extensive one, is to the south of the centre and to the west of the river. This again is a tongue of higher land, the approaches to the Malone Ridge, which was partly built over in the nineteenth century. The upper class of Belfast has traditionally lived in the south of the town. This had its genesis around the castle (1603) and the tradition was maintained when the White Linen Hall was built a little to the south of Castle Place; and Linen Hall Street (now Donegall Place), connecting the site of the castle and the Linen Hall (the site of the present city hall), reflected the newfound wealth of merchants and the older elite in its fine dwellings. The Marquis of Donegall had a town house on the corner of Linen Hall Street. [5] As Belfast grew the retail centre encroached on this preserve, and the select company moved south again. The houses they left, in plain but substantial regency style, bear witness to their gracious living, though they are hardly suited to the office use which has been the fate of those that survived. The outward movement took place along the most important routeway of all – the road to Dublin. This road followed a ridge of sands and gravels into Malone, an area long admired by travellers for its beauty, neat cultivation and English aspect, and above all for its substantial farms and large estates. Small wonder that expansion in this direction

was mainly residential on a grand scale. To the east of the Lagan was the demesne of the Marquis of Donegall; this became a public park (Ormeau Park) in 1865, but it had its effect on the landscape, and the terraces around are similar in style, if on a smaller scale, to those of Malone and the Antrim Road. Old residential terraces are entirely absent from the industrial west, and in the east they form a nucleus so small that it can be disregarded. Traditionally the old residential areas in Belfast are in the north and south.

Most of the terraces in these sectors are three storeyed, often with the addition of an attic storey. Those terraces built before the eighteen-fifties retain much of the dignity of the earlier Georgian houses. The best examples of the unified terrace style remaining in Belfast are in the south — Upper Crescent, Royal Terrace and University Square (Pl. 4c). Later terraces abound in bay windows, and sometimes these have been added to earlier houses. These houses are ill-adapted to the servant-less living of today, and apart from housing doctors and professional men, many of them have now become small private hotels, rooming houses, flats, private schools and institutions. On the whole this type of land-scape region is one of change, though not necessarily with that decay which often accompanies change in such a zone of transition.

The newer regions of Belfast which are characterised by terrace housing and interspersed shopping (aBC) are restricted almost entirely to the industrial districts. They form a western rim, together with an area which approaches the city centre in the south-west and is roughly coincident with floodable land on either side of the Blackstaff river — an area built up in this century. Similarly the eastern industrial area is rimmed by streets which differ from the older core only in being more recently built. Houses are still small, crowded conditions still prevail, and the mill is still an integral part of the landscape. In the south one small region of this type straddles the River Lagan in a region which was shunned by the older residential regions on the higher land on either side.

Beyond this again is a zone of newer terrace housing in which the corner store or parlour shop is absent (abC). Here the shops are confined to the main thoroughfares leading into the city, or, as in the newer estates, they are planned as a group for an entire housing project. This zone is restricted in the east; it straddles the river in the south; and it is most extensive in the west, in a post-war extension of corporation houses. It is also fairly extensive in the north, in an area contiguous with shipping and warehousing.

All the zones discussed so far, with the exception of the older residential zone, are closely connected with industry: one is never far from the sight, smell or noise of a factory. But the final landscape region is free from industry and from interspersed shops. This is the newer residential area of detached and semi-detached housing (abc). The most striking fact of its distribution is its near absence in the west, where industry follows the tributary streams of the Lagan to the very slopes of the Antrim plateau. The small area of new residential housing along the Crumlin Road in the north-west is restricted by the fact that it impinges on older Legoniel. The only other area of this type in the west is in the south-west, at the extremity of the Falls Road. Along this

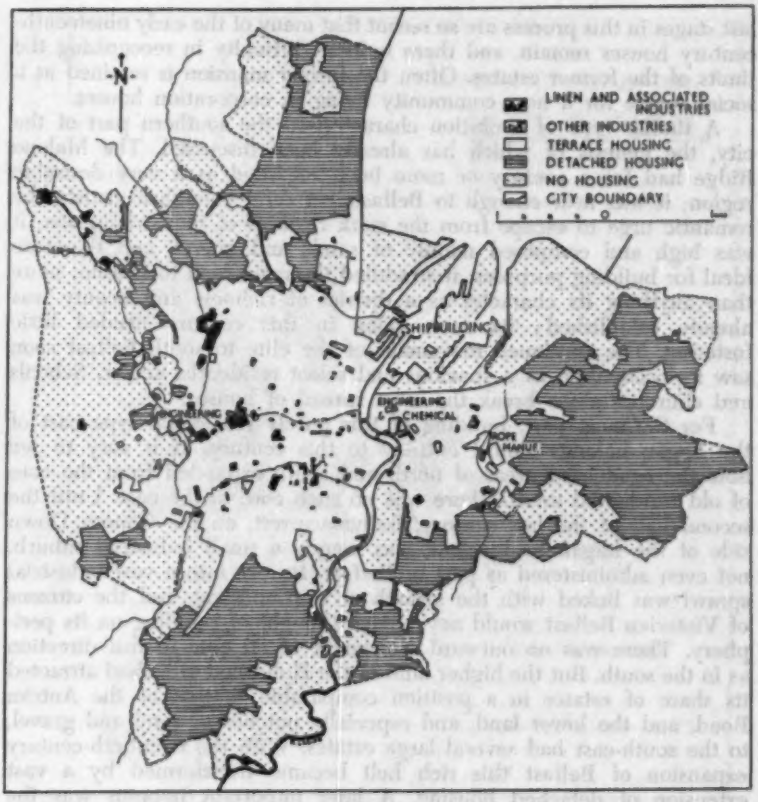


Fig. 3 Belfast : distribution of industries and types of housing.

road the almost exclusively Roman Catholic population has its own social grading, reflected in type of housing; so the further away from the city the more completely residential does the character of this area become.

North, south and east Belfast, however, stand out conspicuously as very extensive areas which are similar in type if not identical in evolution. Extensive from their very nature, they expand far beyond the boundary of the municipal borough. In North Belfast the westward limits are the very steep slopes of Cave Hill, and the eastward limit is the lough shore. This is a sector which has steadily grown less exclusive, from the hunting ground of one family to the eighteenth and early nineteenth-century country estates of rich merchants. Later in the last century and in this there was considerable movement of the growing middle class of professional men and small merchants to this area, which had been protected from industrialisation. Gradually the old estates broke down, giving way to the detached, and eventually to the small semi-detached, villas between Antrim Road and the lough shores. The

last stages in this process are so recent that many of the early nineteenth-century houses remain, and there is little difficulty in recognising the limits of the former estates. Often the former mansion is retained as a social centre for a new community living in corporation houses.

A similar type of evolution characterised the southern part of the city, the genesis of which has already been discussed. The Malone Ridge had for a century or more been regarded as a very desirable region; it was near enough to Belfast, yet rural enough to satisfy the romantic urge to escape from the stark realities of industrialisation; it was high and composed mainly of sands and gravel, and therefore ideal for building purposes; it straddled the main road to Dublin; more than anything its character as a district of richness and beauty was already established; its snob value in this century needed little fostering. The continued movement of the elite to south Belfast soon saw its occupation as a spacious and select residential sector. Schools and churches alone break the even spread of houses.

For the most part, building of this purely residential type east of the Lagan belongs almost entirely to this century. It is easy to see how the residential areas of north and south expanded from the core of old residential areas. There was no such core in the east. Until the second half of the last century, Ballymacarrett, on the County Down side of the Lagan bridgehead, was merely a small industrial suburb, not even administered as part of Belfast. Its rise into a vast industrial sprawl was linked with the growth of ship-building, and the citizens of Victorian Belfast would never have thought of building on its periphery. There was no outward movement of an elite in this direction as in the south. But the higher land of the Holywood Hills had attracted its share of estates in a position comparable to that of the Antrim Road, and the lower land, and especially patches of sand and gravel, to the south-east had several large estates. With the twentieth-century expansion of Belfast this rich belt became transformed by a vast extension of detached housing. A later important impetus was the building of Parliament House on one of these former estates, at Stormont, just outside the city boundary. Although similar in character, then, to north and south Belfast, this eastern area is much later in development, and consequently the scale of building, in houses and avenues, is smaller.

The division of the city into landscape regions on the criteria discussed previously revealed five main types of urban landscape: the old, mainly terraces of houses, with many interspersed shops and closely connected with industry; the old rather select residential areas which are now rapidly changing; new extensions of terrace housing with shops; similar extensions without shops; and lastly detached residential areas. Of the other three possible types, the area of old, residential detached housing is very small indeed and is akin in most features to the old residential areas discussed. Two categories are absent, because interspersed shopping is not found with villa development.

The five categories discussed are not single isolated regions, but rather regions which are found in different parts of the city. Regions

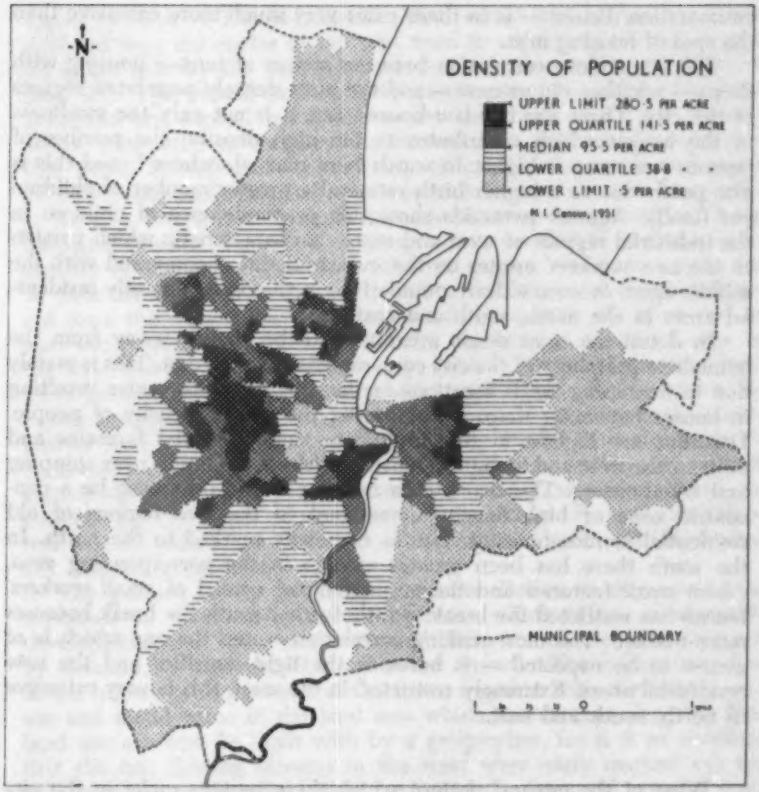


Fig. 4 Belfast: density of population, 1951.

within the same category are comparable environments today (although they may have differed slightly in origin).

The three criteria which were used in the delimitation of these regions were comparatively straightforward and easily mapped. Many other criteria can be correlated with those already discussed. One is the presence of industry, which in one form or another makes itself felt in all except the purely residential regions. This is made clear in the map of the distribution of industries in Belfast, which also shows how areas of detached housing are entirely free from industry (Fig. 3).

Given the physical environments which the map of urban landscape regions suggests, there are many human distributions – such as differences in fertility ratios, segregation index, incidence of disease – which could be correlated with it. The only one included in this paper is the density of population (Fig. 4) [6]. The city centre is very sparsely populated except for its rim, where the occasional small streets are teeming with life. The density here is heavy because it has been calculated on the area of housing only, although the statistical unit – the

enumeration district – is in these cases very much more extensive than the area of housing in it.

There is a close correlation between sectors of terrace housing with shops – whether old or new – and the most densely populated regions of the city. These are bye-law houses, but it is not only the smallness of the houses which contributes to the high density; the number of persons per room is higher in wards here than elsewhere [7], and this is also partly due to a higher birth rate and a greater number of children per family. Age-sex pyramids show this preponderance of children in the industrial regions of west and east – a characteristic which persists in the new workers' estates on the industrial rim – compared with the middle-aged, or even elderly populations in the predominantly residential areas in the north, south and east.

In detail the most dense areas tend to be slightly away from the immediate periphery of the city core, especially in the east. This is mainly due to increasing retail functions in the area near the centre resulting in houses becoming shops and lowering the overall density of people. Densities are highest in the immediate vicinity of the factories and mills in the west and along the northern side of the lough near shipping and warehousing. The two breaks in what would otherwise be a concentric zone of high density correspond to the two regions of old residential terrace housing. This is especially marked in the north. In the south there has been greater change in the corresponding area, where small factories and the accompanying spread of small workers' houses has restricted the break: a little further south the break becomes more marked. The most striking correlation – and the one which is of course to be expected – is between the light densities and the new residential areas. Extremely restricted in the west, this is very extensive in north, south and east.

What of the general pattern which these regions make in the city as a whole? Do they correspond in any way to the theoretical geometric patterns of city development which have been applied by ecologists to urban growth and function? Expansion and the spread of retail functions are two criteria which theoretically – and in the absence of disdisturbing factors – would be expected to give a concentric zonal arrangement, not unlike that postulated by Burgess [8]; and indeed the type of housing, in so far as residential use is found on the periphery where land values are lower than at the centre, might be expected to confirm the concentric pattern. In fairness to the Burgess hypothesis the concentric pattern is meant mainly as an ideal, departures from which are important and have to be explained [9]. In Belfast, however, it would seem that the departures from this pattern are too radical to suppose that they are mere exceptions to a rule. The absence of category AbC except in three well-defined areas, the notable gaps in category aBC, and the nearly complete absence of abc in the west means that the possible zones have completely broken down. The nearest approach is in east Belfast, of newer and more rapid growth, where the old residential – which upsets the zones in the west – is all but absent.

There seems greater justification for trying to apply the sector

theory of Hoyt [10]. This says, briefly, that certain types of land use, once initiated near the centre of the city, tend to expand in sectors, limited on either side by the parallel expansion of other sectors of different land use. This would explain satisfactorily why the older residential areas did not expand westward, where there was already a growing sector committed to industry. Later expansion has merely continued this trend, leaving the west entirely industrial, the north and south entirely residential. Hoyt's hypothesis, however, could not be applied to the east. Nor would its applications in the west fully accord with the historical reasons why these patterns arose, for Hoyt's explanation is crudely mechanistic. Historically, the one region which, in *origin*, fits in with the theory is in the south. Initiated at the southern rim of the old town this region has crept southward, limited by the river and its associated industry in the east and by the greater industrial area of the west. But this is the initiation only. Both north and south residential areas became firmly established in areas which had a high social value *before* the expansion of the town – along the Malone ridge in the south, and on the former line of estates overlooking the lough in the north [11]. In the east, Ballymacarrett had no residential core, but beyond it, as it expanded, there were the substantial demesnes already referred to, overlooking the lough or situated on favoured sandy lowlands. Here was a human landscape not unlike the north and south, which eventually became a residential suburb.

The pattern of the urban landscape in Belfast to-day cannot be explained in terms of geometric patterns which follow mechanistic development, the 'laws' of growth and decay, or economic sorting out by demand, or the restriction of sector growth. The explanation lies in the history of the growth of the town, together with the history and use and social value of the land into which it was expanding [12]. This land use can best be dealt with by a geographer, for it is no accident that the fast flowing streams in the west were early marked out for industrial use, or that the higher lands and the favoured areas of sand and gravel should have been earmarked by rich gentry. It was that land use which had invested the country areas outside the former limits of the eighteenth-century town with social values that often meant more than mere land values. It is in relation to these new values, the product of man's use of the land and later of his regard for having the right kind of neighbour, that the urban landscape of Belfast can best be explained.

[1] Evans, E. E. and Jones, E. The Growth of Belfast, *Town Planning Review*, 1955, XXVI (2).

[2] *Census of Population for Northern Ireland 1951, Belfast County Borough*, 1953.

[3] 16 & 17 *Vic*: An act for the improvement of the borough of Belfast, 1848; 41 & 42 *Vic*: An act for the improvement of Belfast, 1878.

[4] Lawson, James. *A map of the port and harbour of Belfast*, 1789. Linen Hall Library, Belfast.

[5] Evans, E. E. and Jones E. *op. cit.*, p. 97.

[6] The density map, drawn from unpublished 1951 Census figures, is based on enumeration districts. There are 231 such districts in Belfast, making possible a very detailed map. The districts were arrayed according to their densities, and the quartiles and median established. This gave the four densities on which the map is based.

[7] *Census 1951, Belfast County Borough*, 1953, Table 7.

[8] Burgess, E. W. *Proceedings of the American Sociological Society*, 1929, XVIII, pp. 88-9.

[9] Quinn, J. A. The Burgess zonal hypothesis and its critics, *American Sociological Reviewv*, 1940, V (2).

[10] Hoyt, H. *One Hundred years of Land Values in Chicago*, 1933. *The Structure and Growth of Residential Neighbourhoods in American Cities*, 1939.

[11] Jones, E. The social geography of Belfast, *Journ. of the Stat. and Social Inq. Soc. of Ireland*, 1953-54, XX.

[12] Firey, Walter. *Land Use in Central Boston*, 1947. Firey stresses the need to assess culture values in old-established cities.

THE SCOTTISH EAST GREENLAND EXPEDITION

The Scottish East Greenland Expedition spent the summer in the Scoresby Land region of eastern Greenland. Its purpose was to explore and climb the remarkable mountain system of the Steunings Alps, and to carry out field work in connection with arctic mammals (particularly lemming), lichens, glaciology and ornithology.

The nine-man party, assembled from the U.K. and Canada, arrived by charter plane at the landing-strip at Mestersvig on the 10th of July, 1958. At first operations were limited to the eastern side of the range, where exploration of the Baersarker and Kismul glaciers was carried out and the ascent of five virgin peaks was made. When the fjord ice broke up near the end of July, the party moved to the head of Alpe fjord, a long arm cutting off Nathorst Land from Scoresby Land. From a base here the expedition explored the Sefstrom, and Sporre glaciers, and other glaciers leading into Schaffhausers Dal in Nathorst Land, climbing in all eighteen peaks. The range was crossed in a north-south direction for the first time, enabling two parties to visit the northerly eskimo settlement of Syd Kep. The speed and ablation of the Seftrom glacier was measured, and the heights of peaks in the Seftrom area surveyed. On evacuation at the end of August, one party succeeded in traversing the range in a west-east direction via the Gully and Bersarker glaciers, making the first crossing of the highest pass in the range, col major.

A collection of arctic lichens has been presented to Glasgow University for work on nitrogen fixation, and data is being assembled on bird populations.

The members of the party, all mountaineers, were: Dr Malcolm Slesser (leader), Donald Bennet, Roderick Cameron (radio operator and engineer), Kenneth Bryan, Leonard Lovat, Stanley Paterson (glaciologist and surveyor), Charles Rose (artist), Douglas Scott (ornithologist and photographer), Dr Iain Smart (histologist, doctor).

M. S.

SUB-GLACIAL STREAM EROSION IN SOUTHERN NORTHUMBERLAND

J. B. Sissons

A few years ago Peel [1] drew attention to the fact that the floors of two glacial drainage channels in southern Northumberland (Beldon Cleugh and the East Dipton channel) do not decline in height continuously in a single direction but exhibit a marked rise and fall. As yet no satisfactory explanation of the origin of these channels has been put forward. It is the purpose of this paper to suggest such an explanation. As will be seen the importance of this explanation is not only that it accounts for the anomalous features of the two channels but that it provides the key to an interpretation of the mode of deglaciation of southern Northumberland differing considerably from the orthodox interpretation of Dwerryhouse [2], Anderson [3] and Raistrick [4].

Only a brief description of the channels is necessary here since they have been described in detail and excellently illustrated already by Peel [5]. The Beldon channel (Fig. I) is over a mile long, steep-sided, has a maximum depth exceeding 150 feet, and is drained only by tiny streams. The northern part is floored with peat and has a winding course. The evidence from borings made by Peel leaves little doubt that the bedrock floor of the channel has a marked up-and-down profile: commencing at an altitude of about 1,070 feet at the northern end, the bedrock floor rises to at least 1,110 feet about half-way along the channel, before descending to about 1,000 feet at the point where the channel runs into the trench occupied by the Beldon Burn.

The East Dipton channel (Fig. 2) is about three miles long, steep-sided, has a maximum depth exceeding 150 feet, almost lacks peat, and is drained by small streams. The solid floor, which at the western end is at an altitude of 390 feet, rises gradually to a maximum altitude of about 410 feet after half a mile before descending to about 190 feet where the channel becomes continuous with the trench occupied by the March Burn [6].

Both channels cut across the spur to the east of the Devil's Water, a south-bank tributary of the middle Tyne. Numerous other channels occur on this and other spurs to the south of the Tyne. In Peel's words, "Many of these channels fall into aligned sequences at levels steadily declining eastwards, and all the evidence suggests that they were cut to link series of lakes impounded in the valleys of the northward-draining Tyne tributaries by the edge of the Tyne ice-sheet as it retreated north. This interpretation was advanced for the western part of the region in 1902 by Dwerryhouse. More recent work by Anderson in the eastern part of the area confirms and supports this view [7]". Yet despite this definite statement regarding the deglaciation of the area, which is further supported by Raistrick [8], the evidence is far from conclusive.

This evidence is best considered in relation to Dwerryhouse's map [9] of glacial drainage channels and former ice-dammed lakes in the area south of the middle Tyne reproduced in Figure 3. His is the only detailed

published study of the area in which the Beldon and East Dipton channels actually occur. It may be noted that, although Dwerryhouse dealt with the whole of the Alston Block, this is the only detailed map of retreat stages and glacial drainage channels he provided, and it is thus logical to assume that he considered the evidence for deducing the existence of former ice-dammed lakes most satisfactory in this area. The following criticisms of Dwerryhouse's evidence as shown on this map may be made: (i) channel B, supposed to have carried water from lake A to lake C, does not descend to the level of lake C; (ii) the humped bedrock profile of channel E (Beldon Cleugh) is unexplained;

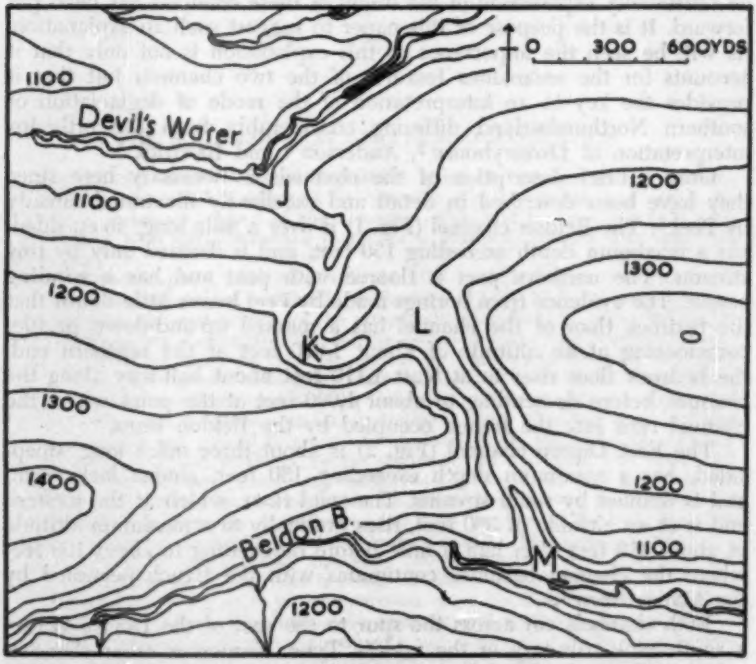


Fig. 1 The Beldon channel (J, K, L, M). Based on Peel, *op. cit.*, 1951.

(iii) no channel is shown draining into lake F; (iv) no continuous channel draining from lake F to H is shown; (v) channel G is shown as terminating well above the level of the lake into which it is supposed to drain. Thus the ice-margin positions drawn by Dwerryhouse do not appear to be consistent with his own evidence. The lakes do not constitute evidence, of course, since he deduced their existence and extent from the channels.

In addition to these detailed criticisms a more important difficulty is encountered when the relative rates of retreat of the ice-margin at different points along its length are considered. According to Dwerryhouse's map the ice must have been far thicker in the valleys than on

the intervening spurs. (For example at Stage I the ice would be some 600 feet thicker in the East Allendale valley than on the spur immediately to the west). It is extremely difficult to see how this very thick ice in the valleys melted back at approximately the same rate as the much thinner ice on the spurs in order to maintain the approximately-parallel retreat of fairly-straight ice-margins mapped by Dwerryhouse, even when allowance is made for more rapid melting of the ice where it was in contact with lake waters. Even if his Stage I position of the ice-margin is correctly mapped (and the evidence above suggests it is not) the ice, as it thinned, would inevitably become closely related to

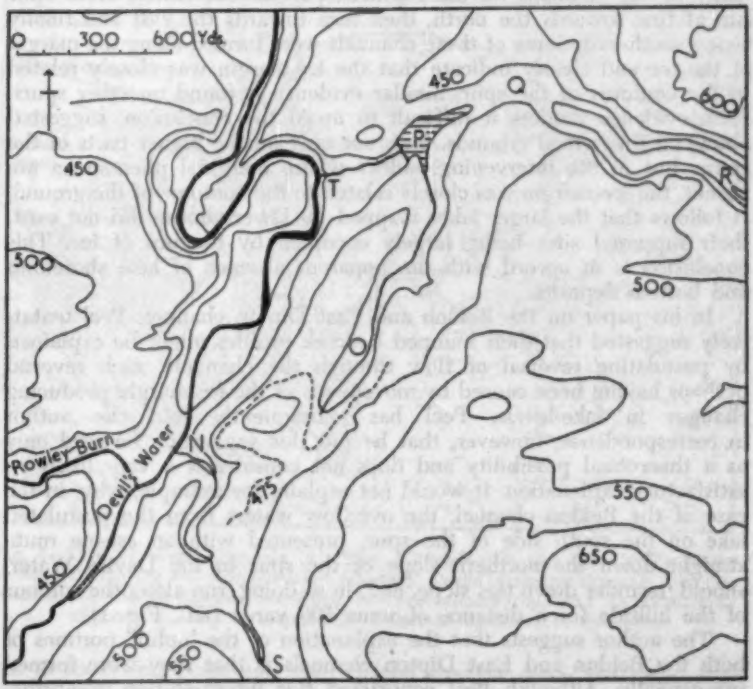


Fig. 2 The western part of the East Dipton channel (T, P, Q, R), its tributary channel (N, O, P) and the western part of the Strothers Dale channel (S). Based on Peel, *op. cit.*, 1951, and Ordnance Survey.

the contours, tongues of ice lying in the valleys and the intervening spurs rising above the surface of the ice.

The Stage I position of the ice-margin also can be criticised on theoretical grounds. Dwerryhouse stated that this stage marks the maximum extent of the ice. It follows that, on his interpretation, at least in the final stages of the advance to the maximum, the ice pushed up the valleys as a vertical or near-vertical wall hundreds of feet high while the much thinner ice over the intervening spurs advanced at approximately the same rate. This appears highly unlikely and is not

in accord with observations on present-day glaciers. One would expect tongues of ice to have advanced up the valleys. One must therefore conclude that the positions of the ice-margin mapped by Dwerryhouse are not justified by his own evidence, while they appear unlikely on theoretical grounds.

Partly in order to test the validity of Dwerryhouse's principal evidence, namely the glacial drainage channels, the author re-mapped some of these channels. This showed that many of the channels Dwerryhouse had mapped as more or less straight trenches across spurs [10] in fact run round the slopes of these spurs. Thus Figure 4 shows that many of the channels on the southern part of the Eshell Moor spur run at first towards the north, then turn towards the east and finally swing south-east. Some of these channels were formed along the margin of the ice and clearly indicate that the ice-margin was closely related to the contours of the spur. Similar evidence is found on other spurs. Such evidence renders it difficult to avoid the conclusion, suggested above on theoretical grounds, that, not only on the higher parts of the spurs, but in the intervening valleys where marginal phenomena are absent, the ice-margin was closely related to the contours of the ground. It follows that the larger lakes mapped by Dwerryhouse did not exist, their supposed sites being largely occupied by tongues of ice. This conclusion is in accord with the apparent absence of lake shorelines and bottom deposits.

In his paper on the Beldon and East Dipton channels Peel tentatively suggested that their humped bedrock profiles might be explained by postulating reversal of flow through the channels, such reversal perhaps having been caused by movements of the ice-margin producing changes in lake-levels. Peel has subsequently told the author in correspondence, however, that he put this suggestion forward only as a theoretical possibility and does not consider it a very likely or satisfactory explanation. It would not explain, for example, why, in the case of the Beldon channel, the overflow waters from the postulated lake on the south side of the spur, presented with an escape route straight down the northern slope of the spur to the Devil's Water, should meander down this slope, and, in so doing, run along the contour of the hillside for a distance of some 600 yards (KL, Fig. 1).

The author suggests that the explanation of the 'uphill' portions of both the Beldon and East Dipton channels is that they were formed sub-glacially. Although Peel considered this interpretation unsatisfactory in his 1951 paper [11] he appears more favourably disposed towards it in a more recent paper [12], and states that Mannerfelt "strongly advocated" it to him, although at the same time he (Peel) mentions several difficulties that it encounters.

Reasons have already been given for believing that ice, not a lake, occupied the valley of the upper Devil's Water at the time the Beldon channel was formed. The channel itself provides further evidence for this view, for the lake hypothesis, in addition to failing to explain (i) the humped bedrock floor of the channel, does not account for (ii) the 600-yard section of the channel running along the south side of the Devil's Water valley, (iii) the fact that the channel commences at the edge of the incised course of the Devil's Water, (iv) the fact

that the channel leaves the incised course of the Devil's Water exactly at the point where the present stream abruptly changes direction through 45 degrees, and (v) the feeble development of the northern side of the channel for the first 300 yards of its course.

Section KL of the channel (Fig. 1) could have been formed only when ice occupied the valley, the meltwaters being forced to flow along the contour of the hillside between the ice to the north and the rising ground to the south. Therefore KL was initiated either as a marginal or sub-glacial channel. The waters that cut KL crossed the pre-existing

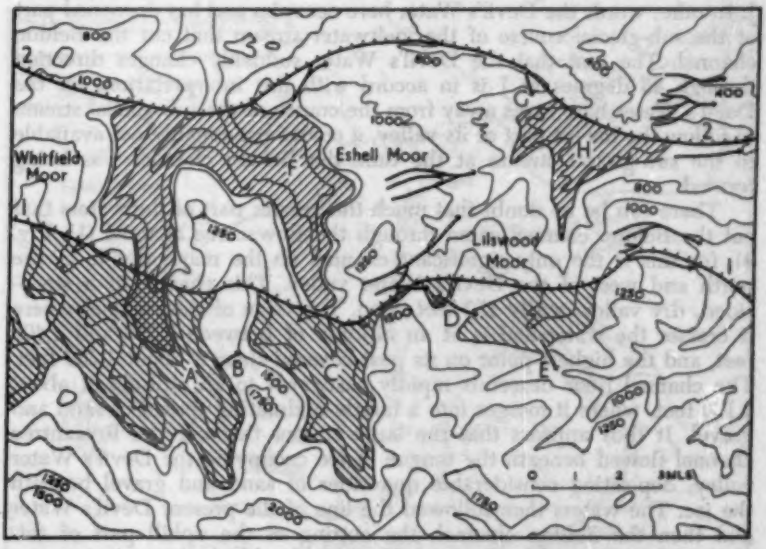


Fig. 3 Map of West Allendale (A), East Allendale (C) and the Devil's Water valley (H) showing ice-dammed lakes (shaded), glacial drainage channels and two positions of the ice-margin, according to Dwerryhouse *(op. cit.)*. D, Rowantree channel. E, Beldon Cleugh. Other letters explained in the text.

col at its lowest point and then flowed straight down the south side of the spur into the Beldon Burn valley, and thence along that valley and into the Derwent valley, cutting the deep trench described by Dwerryhouse and Peel. As the ice on the north side of the spur thinned and its edge retreated down the slope, KL functioned as a marginal channel (regardless of whether or not it was *initiated* as a marginal channel) and both KL and LM were cut deeper.

The waters that cut KLM must have flowed along the channel from J, for JM is one continuous feature, and at K, where one might expect to find an important marginal channel leading into and continuous with KL, no such channel exists. Therefore, whether KL functioned as a marginal channel throughout the time it was in use or was initiated as a sub-glacial feature, JK was certainly entirely formed sub-glacially. This is in accord with other evidence, for there appears to be no other

way in which the southward rise in the bedrock floor of the channel from J to K could be explained. The feeble development of the northern side of the channel for the first 300 yards of its course can also be explained: since there are no grounds for postulating the removal by 'post-glacial' erosion of much of this side of the channel one is forced to conclude that the missing upper part of the channel side was ice (*i.e.* the northern side of a sub-glacial tunnel).

The fact that the channel starts at the very edge of the incised course of the Devil's Water strongly suggests that the waters that cut the channel flowed along the line of the Devil's Water immediately above J. In other words the Devil's Water here occupies and has deepened part of the sub-glacial course of the meltwater stream that cut the Beldon channel. The fact that the Devil's Water suddenly changes direction through 45 degrees at J is in accord with this interpretation, for the Devil's Water here turns away from the course of the sub-glacial stream to follow the lowest part of its valley, a course presumably not available to the sub-glacial stream at the time the Beldon channel was being formed.

There can be no doubt that much the greater part of the waters that cut the Beldon channel came through the Rowantree channel (U, Fig. 4), for this is the only significant channel on the major divide to the north and west of the Devil's Water valley. This channel is a steep-sided, dry valley nearly 150 feet deep. The edge of the channel where it crosses the watershed is at an altitude of between 1,350 and 1,400 feet, and the highest point on its peat-covered floor is about 1,260 feet. The channel floor descends rapidly eastwards to an altitude of about 1,100 feet, where it merges into a faintly-undulating spread of sand and gravel. It thus appears that the large stream that cut the Rowantree channel flowed beneath the tongue of ice occupying the Devil's Water valley, depositing considerable quantities of sand and gravel beneath the ice. The waters then followed the line of the present Devil's Water and then the Beldon channel, the cutting of the uphill part of this channel being possible owing to the considerable hydrostatic pressure under which the waters were flowing.

The East Dipton channel, like the Beldon channel, commences at the edge of the incised course of the Devil's Water and leaves that stream at a sharp bend in the latter's course (Fig. 2). In fact in this case the connection between the course of the Devil's Water and that of the channel is even more obvious, for not only does the Devil's Water head straight for the channel entrance before twisting away in two incised meanders, but the channel "commences as a wide flat-floored trench cut down at least 60 feet *below* the general floor-level of the old valley, and opening out directly from the side of the.... trench of the Devil's Water [13]". There can thus be no doubt that, at least in the final stages of the cutting of the East Dipton channel, the meltwaters followed the present incised course of the Devil's Water before turning away at T (Fig. 2) to follow the channel. The solid floor of the channel rises eastwards some 20 feet between T and Q. Since a surface stream could not cut such an uphill channel one is forced to the conclusion that this part of the channel at least was formed sub-glacially. It follows that for some distance upstream from T the 100-feet-deep trench of the

Devil's Water also was initiated and cut to a considerable depth by sub-glacial stream erosion.

Unlike the Beldon channel the East Dipton channel is joined by a tributary channel (NOP, Fig. 2). This channel starts at the edge of the Devil's Water trench as a broad, shallow, dry hollow, some 10 to 20 feet deep, floored with sand and gravel. It deepens gradually northwards to its junction with the East Dipton channel, where it is some 40 feet deep and its floor is at an altitude of 395 feet. That a considerable part of the waters that cut this channel came down the Rowley

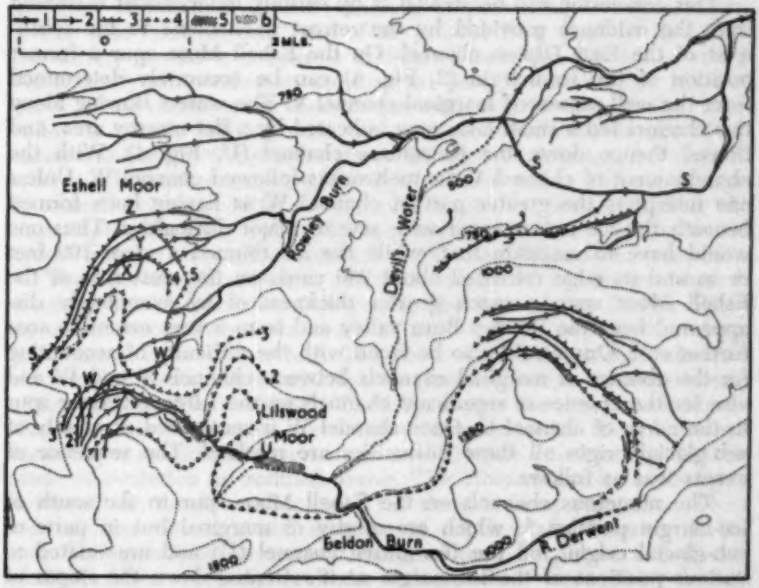


Fig. 4 The Beldon and East Dipton channels in relation to adjacent glacial drainage channels. 1. routes followed by large volumes of meltwater for considerable periods; 2. other glacial drainage channels; 3. positions of the ice-margin accurately mapped from marginal features; 4. other positions of the ice-margin; 5. site of former lake; 6. area of sand and gravel situated between channel U and the Beldon channel; S. Strothers Dale channel; U. Rowantree channel; V-Z other channels referred to in the text.

Ice-margin position 1 is for the most part deduced from the relationship between channel U and the Beldon channel and is to be regarded as provisional. It is possible that the Beldon Burn valley was filled with ice at this stage, in which case the deep trench that the burn occupies would have been cut sub-glacially.

Burn valley is strongly suggested by the precise alignment of the lower part of this valley with the upper part of the channel. It might appear from Figure 2 that channel NOP was formed along the edge of an ice-tongue projecting southwards into the Devil's Water valley. This explanation would be inadequate, however, for it would mean that on entering the East Dipton channel the meltwaters from NOP flowed uphill for several hundred yards (from P to Q). Furthermore it would

fail to explain how the East Dipton channel was initiated, for the altitude of the floor of the col into which this channel was cut was approximately 500 feet (unless one assumes, without evidence, a pre-existing channel in the floor of the col). Therefore, in order to develop the necessary hydrostatic head to permit the initiation by a sub-glacial stream flowing uphill of the western part of the East Dipton channel, the ice-margin at that time must have been situated a considerable distance to the south and south-west, in which case the whole of channel NOP and at least the eastern part of the Rowley Burn trench are of sub-glacial origin.

This conclusion can be arrived at by entirely independent reasoning from the evidence provided by the retreat phenomena to the south-west of the East Dipton channel. On the Eshell Moor spur a former position of the ice-margin (2, Fig. 4) can be accurately determined from the well-preserved marginal channel V. The waters flowing along this channel fed a small lake, now indicated by a flat marshy area, and flowed thence down the Rowantree channel (U, Fig. 4). With the abandonment of channel V the meltwaters followed channel W. Unless one interprets the greater part of channel W as having been formed beneath the ice one is faced with several major difficulties. Thus one would have to maintain that, while the ice thinned a mere 100 feet or so and its edge retreated about 250 yards on the west side of the Eshell Moor spur, a much greater thickness of ice completely disappeared from the Rowley Burn valley and from a very extensive area further east. One would also be faced with the difficulty of accounting for the absence of marginal channels between channels V and W and also for the absence of significant channels on the Lilswood Moor spur to the north of channel U. Once channel W is recognised as mainly of sub-glacial origin all these difficulties are resolved. The sequence of events was as follows.

The numerous channels on the Eshell Moor spur to the south of ice-margin position 2, which are mostly of marginal but in parts of sub-glacial origin, fed the Rowantree channel (U) and are related to various positions of the ice-margin as it retreated down the slopes of the spur. The last channel (V) to feed channel U was formed along ice-margin 2. While V was being formed increasing quantities of meltwater had found their way beneath the ice-margin, particularly along the three channels that join the western part of W. Eventually channel V was completely abandoned (and consequently channel U also) and all the meltwaters coming from the west followed channel W, disappearing beneath the ice occupying the Rowley Burn valley. Meanwhile the ice on the west side of the spur had retreated from position 2 to position 3. The absence of marginal channels between V and W is thus accounted for.

With continued retreat of the ice-margin channel W was eventually abandoned and the meltwaters crossing the Eshell Moor spur followed channels X, Y and Z, at successively lower levels to the north. As in the case of channel W, the waters flowing through these channels flowed beneath the ice occupying the Rowley Burn valley, for all four channels are deep trenches continuous with the Rowley Burn trench, which is in turn continuous with the Devil's Water trench. This implies

that a major sub-glacial stream followed the Rowley Burn to its junction with the Devil's Water, a conclusion supported by the absence of significant channels on the Lilswood Moor spur to the north of channel U. This also accords with the suggestion made above that the alignment of the upper part of channel NOP (Fig. 2) with the lower end of the Rowley Burn trench implies that most of the waters that cut channel NOP had come under the ice down this trench.

The sub-glacial Rowley Burn did not at first continue into channel NOP (Fig. 2), however. Instead it followed the Strothers Dale channel (S, Fig. 4). This channel, mapped in part by Dwerryhouse [14], resembles the East Dipton and Beldon channels in possessing an up-and-down profile (the "downstream" rise of its present floor is about 100 feet), but differs in that it is broader and less deeply cut (80 feet at most). Significantly the south-eastward-directed part of the first few hundred yards of its course as it ascends the east side of the Devil's Water valley is exactly aligned with the point at which the Rowley Burn enters the Devil's Water valley from the west. It thus appears that the sub-glacial waters descending the Rowley Burn valley first cut channel S, secondly channel NOP and its continuation as section PQR of the East Dipton channel, and finally the upper 50 or 60 feet of the Devil's Water trench (NT) and section TP of the East Dipton channel.

Thus the simple sequence of events described by Dwerryhouse [15] whereby the channels on the spur to the east of the Devil's Water were cut successively from south to north as the overflows of large ice-dammed lakes is incorrect. The three up-and-down channels were cut in order from south to north by sub-glacial waters, but independently of the other (smaller) channels. The large size of the three up-and-down channels clearly indicates that large volumes of water flowed through them for a considerable period of time. This is consistent with their mode of evolution as outlined above. The other channels on the spur, however, are much smaller: most of them start as faint benches or very shallow channels and increase in depth gradually towards the east. These channels are mostly marginal (and, in places, sub-glacial) channels. Their relatively small size is due to their waters being derived locally and to the short time they were in use, while their eastward increase in depth is largely due to the increased quantities of water available for their excavation in this direction (principally from melting of the adjacent ice). This is in direct contrast with the three sub-glacial channels which are of large dimensions throughout, having been cut by large volumes of water not derived from their own immediate vicinity.

Probable criticisms of the interpretation suggested above have been indicated by Peel [16], who states: "Many problems are of course involved in such a concept including the ability of sub-glacial streams to erode large channels in solid rock, the possibility of their eroding uphill under hydrostatic head, and perhaps even the possibility of major concentrated meltwater streams flowing at all under thick land ice..."

Although little attention has been given in Britain to erosion by sub-glacial streams its importance has long been recognised on the Continent. Mannerfelt [17] and others have described and mapped numerous valleys cut by waters that flowed from ice-free ground

beneath the ice where the latter terminated against steeply-rising ground. Examples abound in Britain but appear not to have been described as yet. The writer has mapped many channels of this type in East Lothian, where they range up to 100 feet in depth and are usually cut in solid rock [18].

The tunnel valleys of eastern Denmark (tunneldale) and north Germany (Rinnentäler) are regarded by most authorities as having been formed by sub-glacial streams. Thus Schou [19] states that the larger tunnel valleys in Denmark are up to 75 km. long and over a kilometre wide, while the surrounding glacial landscape often lies 100 metres above the valley bottom. Regarding their origin Schou [20] says: "These valleys were formed by the erosion of the meltwater under the ice-cap. In tunnels which they formed under the ice the enormous masses of water moved with such great erosive force that they were able to cut the tremendous sub-glacial gutters which now appear in the form of large valley systems or transgressed by the sea as in the case of the East Jutland fiords. The great thickness of the ice-cap and the resulting high watertable in the ice subjected the meltwater in the tunnels to high pressure, so that locally within these enclosed ducts it ran uphill. This phenomenon is also observable in present-day glaciers, where in some cases the meltwater has been seen to emerge from the 'gates' like a fountain, having run obliquely upwards along the final stretch." These large sub-glacial valleys greatly exceed in size the channels in Northumberland that the author suggests are of sub-glacial origin. In particular it may be noted that the 'downstream' (westward) rise in the floors of the sub-glacial valleys in Denmark sometimes approaches 100 metres, a figure greatly exceeding that in the Northumbrian examples.

Evidence of sub-glacial stream flow and its relation to ice-dammed lakes in areas at present undergoing glaciation is in accord with the deductions made concerning the Northumbrian channels. Proof that sub-glacial streams are eroding their beds, particularly that they are in some instances eroding when flowing uphill under hydrostatic pressure, is obviously difficult to obtain. However, Okko has stated [21] that in Iceland, at least in the case of Hoffelsjökull, Heinabergsjökull, Breidamerskurjökull and Skeidararjökull, sub-glacial waters "must flow uphill in order to emerge from the ice" and therefore "must.... flow under hydrostatic pressure". Ahlmann [22], Arnborg [23], Thorarinsson [24] and Jónsson [25] have made similar observations regarding streams issuing from the base of the ice in this area. Arnborg states that in these conditions "the sub-glacial rivers may have a great capacity and eroding force" [26], while Jónsson says: "There is no doubt that the ice-river does a tremendous erosive work beneath the ice where there is no rock to stop it. When the river has eroded off the loose material which is the bed, the ice must, of course, sink down and on account of the hydrostatic pressure, the ice-river may continue its erosion deeper down according as the thickness of the ice above" [27].

It should also be mentioned that the draining off of ice-dammed lakes by streams flowing beneath the ice is a common phenomenon in Iceland. The opening of a tunnel beneath the ice during the summer may rapidly empty an ice-dammed lake, the waters re-appearing at the snout of the glacier several miles away producing sudden floods.

Arnborg [28], using his own evidence and Thorarinsson's researches [29], suggests that, as the ice thins over the course of years, these floods probably become less intense (owing to the sub-glacial outlet being opened earlier in the summer), eventually ceasing completely when the sub-glacial tunnel exists as a permanent feature.

The explanation advanced above for the origin of the Beldon and East Dipton channels may appear unsatisfactory in that it requires sub-glacial streams to have followed valley floors and then suddenly to have abandoned them in order to climb valley sides and flow through pre-existing cols. It must therefore be pointed out that such sub-glacial stream courses are quite common, for in some areas the evidence of eskers clearly shows that sub-glacial streams often followed such routes. For example, Mikkola [30] mentions five esker systems that cross the mountain belt of northern Lapland "availing themselves of the gaps and valleys which interrupt it". He continues: "Thus they follow the general rule of adjusting themselves to the larger topographic features." A similar generalisation is made by Flint [31], who states: "..... an esker may climb up a valley for several miles, pass over a low divide, and descend the far slope. Crossings of divides are invariably at low saddles or gaps, and at such a crossing the esker is likely to be notably discontinuous". One esker in northern Lapland discussed in detail by Mikkola [32] follows the valley of the Sotajoki river for a considerable distance before leaving it at an abrupt bend (cf. Beldon and East Dipton). The esker then climbs 100 metres up the valley side to near the crest of the interfluve, where it is continued by a "zone of conspicuous erosion phenomena", which extends down to the floor of the next major river valley. Examples in Britain have been mapped by F. Synge, who kindly allows the author to quote from his unpublished work. One esker on the Aberdeenshire/Kincardineshire border, mapped by Synge, is several miles long and crosses two spurs on either side of the Water of Aven, a south-bank tributary of the eastward-flowing Water of Feugh. Commencing near the Feugh at about 400 feet the esker rises eastwards to 450 feet before descending below 400 feet where it has been breached by the Aven. It then climbs again and ends slightly above 450 feet in a meltwater channel cut into the floor of a pre-existing col. The esker commences again at the lower end of the channel and descends to near the floor of the Burn of Strathy, which it follows to the confluence of the Strathy with the Feugh. More striking examples have been mapped by Synge in Leix County in central Ireland. Here the Stradbally and Maryborough eskers climb steadily towards hilly country from altitudes of between 250 and 300 feet to altitudes of between 400 and 500 feet. Each esker makes for a pre-existing col where it is replaced by signs of meltwater erosion that merge into a well-developed meltwater channel on the further side of each col.

It is suggested that these notes on sub-glacial drainage in Iceland and in areas formerly ice-covered, especially as evidenced by eskers and related erosional features, coupled with the detailed evidence from southern Northumberland, leave little doubt as to the former importance of sub-glacial drainage in the latter area.

It is not proposed to consider here the application of the conclusions reached above to other parts of Britain. The author ventures to

suggest, however, that much that has been written in Britain on glacial retreat stages as deduced from glacial drainage channels is in need of considerable revision. It may be added that the author is not alone in making this suggestion for orthodox views have long been challenged by Carruthers [33] for very different reasons, while Peel [34] has rightly pointed out that in Britain "thought has been perhaps unduly influenced by Kendall's concept of freely-draining lakes despite the common and disturbing lack of any independent direct evidence for such lakes".

The author wishes to thank Professor R. F. Peel for discussing this paper in detail with him and for making several valuable suggestions. He would also like to thank Mr F. M. Synge for permitting him to quote from unpublished work.

[1] Peel, R. F. A study of two Northumbrian spillways. *Trans. Inst. Brit. Geogr.* for 1949 (1951), 15 : pp. 73-89.
[2] Dwerryhouse, A. R. The glaciation of Teesdale, Weardale, and the Tyne valley, and their tributary valleys. *Quart. Journ. Geol. Soc.*, 1902, 58 : pp.572-608.
[3] Anderson, W. Buried-valleys and Late-glacial drainage systems in North-West Durham. *Proc. Geol. Assoc.*, 1940, 51 : pp. 274-281.
[4] Raistrick, A. Glaciation, in Contributions to the geology of Northumberland and Durham. *Proc. Geol. Assoc.*, 1931, 42 : pp. 281-290.
[5] Peel, R. F. *Op. cit.*
[6] *Ibid.*
[7] *Ibid.*, pp. 73 and 77.
[8] Raistrick, A. *Op. cit.*
[9] Dwerryhouse, A. R. *Op. cit.* p. 600.
[10] *Idem.*
[11] Peel, R. F. *Op cit.*, p. 87.
[12] Peel, R. F. The profiles of glacial drainage channels. *Geogr. Journ.*, 1956, 122 : pp. 483-487.
[13] Peel, R. F. *Op. cit.*, 1951, p. 85.
[14] Dwerryhouse, A. R. *Op. cit.*
[15] *Ibid.*
[16] Peel, R. F. *Op. cit.*, 1956, p. 486.
[17] Mannerfelt, C. M. Nagra glacialmorfologiska formelement. *Geograf. Annaler*, 1945, 27 : pp. 3-239.
[18] Sissons, J. B. The deglaciation of part of East Lothian. *Trans. Inst. Brit. Geogr.*, No. 25.
[19] Schou, A. The Landscapes, in *Atlas of Denmark* (text and photographs), ed. by N. Nielsen. Copenhagen, 1949.
[20] *Ibid.*, pp. 83-84.
[21] Okko, V. Glacial drift in Iceland, its origin and morphology. *Bull. de la Comm. Géol. de Finlande*, No. 170, 1955, p. 83.
[22] Ahlmann, H. W. *Land of Ice and Fire.* 1938, p. 191.
[23] Arnborg, L. Ice-marginal lakes at Hoffellsjökull. *Geograf. Annaler*, 1955, 37 : pp. 202-228.
[24] Thorarinsson, S. The ice-dammed lakes of Iceland with particular reference to their values as indicators of glacier oscillations. *Geograf. Annaler*, 1939, 21 : pp. 216-242.
[25] Jónsson, J. On the formation of frontal glacial lakes. *Geograf. Annaler*, 1955, 37 : pp. 229-233
[26] Arnborg, L. *Op. cit.*, p. 228.
[27] Jónsson, J. *Op. cit.*, p. 231.
[28] Arnborg, L. *Op. cit.*, pp. 202-203.
[29] Thorarinsson, S. *Op. cit.*
[30] Mikkola, E. On the physiography and Late-glacial deposits in northern Lapland. *Bull. de la Comm. Géol. de Finlande.* No. 96, 1932, p. 76.
[31] Flint, R. F. *Glacial Geology and the Pleistocene Epoch.* 1947, p. 150.
[32] Mikkola, E. *Op. cit.*, pp. 56-58 and Plate II.
[33] Carruthers, R. G. On Northern glacial drifts : some peculiarities and their significance. *Quart. Journ. Geol. Soc.*, 1939, 95 : 299-333.
[34] Peel, R. F. *Op. cit.*, 1956, p. 486.

Pl. 1

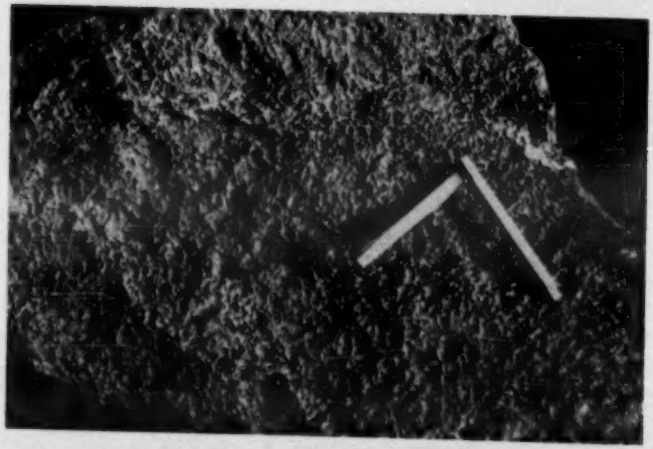
Corrosion forms in limestones

(a) - top left - Les Grenettes; Isle of Ré: *Clionae* action, advanced stage.

(b) - top right - Lost'march, Crozon Peninsula: small corrugations in spray zone: honeycomb pattern in Ordovician limestone.

(c) - bottom left - Llanes, Asturias: sloping platform with ponds in Dimantian limestone.

(d) - bottom right - Lost'march: flat-bottomed ponds with overhangs in neap-tide zone; mussels, not responsible for overhangs.



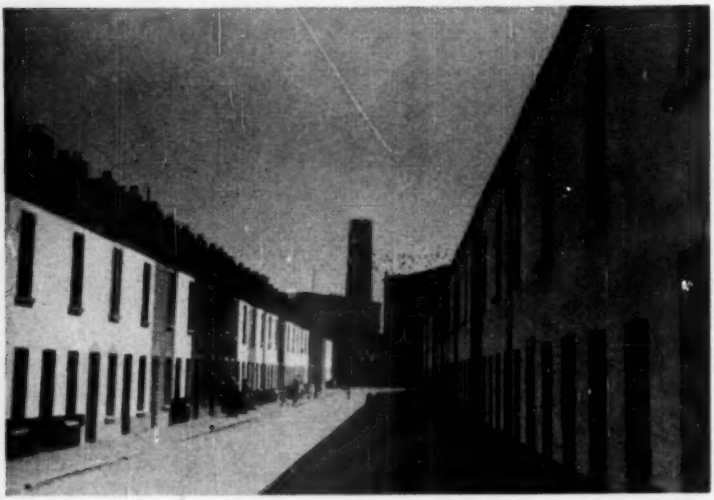
Pl. 2 Lake Gredos, Avila

L. Gredos in foreground occupies deepest part of the great cirque at the head of River Gredos; beyond are smooth polished rocks of higher part of cirque floor, above which rise steep jagged walls, culminating in crests over 2,300 m.; the latter, which were never submerged by the Quaternary ice, show the effects of intense frost-shattering; snow persists all the year arround at these altitudes.

National Spanish Tourist Office, London.

Pl. 3
Guisando, Avila. A nucleated village settlement very similar in size and appearance to El Arenal. It lies about 5Kms W.N.W. of Arenas de San Pedro, at 800 m. Two peasant women in typical dress seated by cobbled track. Houses behind packed closely together along maze of narrow alleys; they are built of granite or local brick with framework of timber, with red-tiled roofs and small windows without glass. Behind village rise steep slopes with chestnuts clothing lower, and pines upper parts.

National Spanish Tourist Office, London.



Pl. 4 (a)

West Belfast; Bye-law housing, 1850-70, Zone ABC: note mill in background.

Pl. 4 (b)

Corner stores typical of Zone ABC.

Pl. 4 (c)

University Square, 1840's, Zone ABC, in transition; very few houses now used as dwellings, the remainder housing University departments.

THE SIERRA DE GREDOS

BARBARA DRESSER

An Edinburgh University Biological Expedition to Spain, supported by the University Court and Cross Trust, was based in the Gredos Mountains from the 13th of July to the 14th of August 1956. The main camp, at 950 m. near the village of El Arenal, was a good base from which to study the economic life, especially land use, of a typical valley of the southern slopes; while a few days in a subsidiary camp at 1800 m. near the Refugio de Club Alpino, provided the chance to see contrasting scenery of Alpine grandeur. This short article is based on observations made during this expedition.

THE Sierra de Gredos, rising to over 2,500m., is the highest range of the Central Cordillera of Spain which sweeps across the inner tableland from west to east dividing Old Castile to the north from the middle Tagus lowlands and New Castile to the south (Fig. 1). The Central Cordillera offers great diversity of relief, land use and human occupants compared with the monotony and uniformity of the Meseta to both the north and the south. Uniformly flat and treeless expanses are characteristic of the high Meseta, and this, together with a climate of extremes and great aridity, limits the range of possible crops so that agriculture is extensive and population scanty. In contrast, a great range of altitude and diversity of relief combined with a more favourable climate give the Cordillera many different types of land use and population density and a way of life which varies accordingly.

Geologically, the Cordillera is a prolongation eastwards of the Archean granitic core of north-west Spain. The backbone of the Sierra de Gredos is a broad ridge over 2000m. extending from north-north-east to south-south-west, widening and rising westwards to culminate in Almanzor at an altitude of 2,592m. Owing to the lower base level of the middle Tagus lowlands to the south of the ridge, the southern flanks are very steep while the northern slopes are gentle; there is consequently a great contrast in the topography of the two sides (Fig. 2). The southern slopes are deeply dissected by youthful torrents and steep-gullied flanks rise abruptly from narrow valley floors to frost-shattered peaks and ridges; El Arenal valley in the south-east is characteristic. On the other hand, to the north of the main ridge, a pre-existing peneplain character is still sufficiently retained to give plateau-like and rounded forms, with suggestions of erosion surfaces, especially at 1500m.

The Sierra de Gredos is one of the few mountain ranges of Spain rising high enough to have been affected by valley glaciers during the Quaternary Ice Age [1] (Fig. 1). Only the valleys of the northern slopes lying above 1,400m. have been modified by glaciation. The absence of glacial forms or deposits on the southern slopes can probably be attributed to less favourable morphological and climatic conditions for harbouring snow [2]. The outstanding centre of glacial forms lies in the area known locally as the "Picos" [3] which comprises three river valleys, the River Gredos with its tributaries the Pinar and Pozas, which rise amongst the highest peaks and crests of the range (Fig. 3). Other

glaciated valleys occur to the west and also to the east where those of Lanchosa and Conventos, lying to the north-west and north respectively of the peak La Mira (2,341m.) are most important [3].

These glacial valleys show similar features. At the head of each is a cirque gouged out of the granite and sometimes occupied by lakes, as for instance Lake Gredos, 60m. deep, in the great cirque in which the Gredos glacier originated (Pl. 2) and further west the Five Lakes in the cirque of the Pinar [4]. Each cirque is encircled by high peaks and crests, the highest of all, including Almanzor (2,592m.) and others over 2,300m. surround the Gredos cirque whose outlet lies at 1,935m. Further testimony of glacial erosion is to be found below the cirques in the U-shaped profiles and polished surfaces of the valley sides. The limits of glacial action are clearly marked by terminal and lateral moraines in most cases. The longest tongue glacier, of 8.5 km., occupied the Gredos valley, that in the Pinar valley was just over 7 km. long but the other three mentioned above were less than 4 km. in length.

The altitudinal limits to which the glaciers descended can be estimated from the heights of the lower limits of the moraines. In the five valleys considered above, these limits are from west to east as follows :— Pinar (1,400m.) [2]; Gredos (1,410m. [2]; Pozas (1,900m.) [2]; Lanchosa (1,510m.) [3]; Conventos (1,620m.) [3]. With the exception of the Pozas valley, this limit descends from east to west as it does in the Central Cordillera as a whole. This has been ascribed to the effects of increasing Atlantic precipitation to the west [1].

One of the greatest problems which arises in studying the glaciation of the area is the question as to how many phases affected it. It is believed by those who have studied the evidence that the Sierra de Gredos was probably affected by two phases, as was the rest of the Central Cordillera [1]. It is also considered that the inter-glacial periods were probably semi-arid and not fluvial so that there is a preservation of both Riss and Würm moraines. (Quaternary Congress in Madrid, 1957).

The extreme range of temperature between summer and winter and the severe summer drought characteristic of the high Meseta of Spain are here modified by altitude. Summer temperatures are slightly cooler than those in the surrounding plains but the desiccating power of the sun and summer drought are still the main factors to be reckoned with in the economic life of the area. The winters are cold and as rainfall is almost entirely confined to these months, it is largely in the form of snow. The annual precipitation of Arenas de San Pedro at 460m. on the south slopes varies very much from year to year from about 750 mm. to 2,000mm. [5] (See Figure 4, which compares the rainfall of Areas de San Pedro with that of Madrid at 655m. on the tableland of New Castile).

The great range of altitude in the Sierra de Gredos has a corresponding range of vegetation. Above 1,600m. there is an alpine belt which includes a large part of the plateau-like area to the north of the ridge. Between 1,600m. and 1,200m., though in places stretching considerably lower, is a belt of pine forest. Finally, below 1,200m. is a belt of terraced agriculture with chestnut forest dominating above 900m. and olives below that altitude. (Fig. 5).

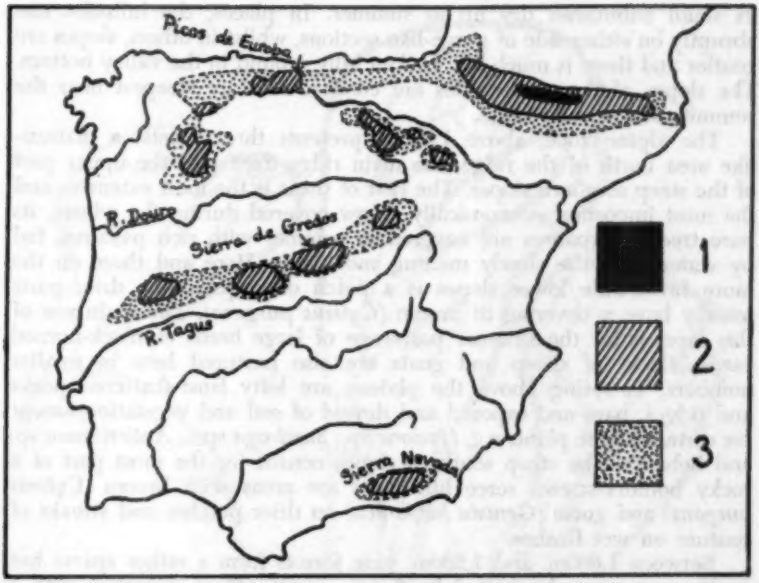


Fig. 1 Distribution of Quaternary glaciers in Spain.
1. zone of existing glaciers; 2. former extent of Quaternary glaciers; 3. zone covered with snow for at least half the year at present. Modified from Sole Sabars [1].

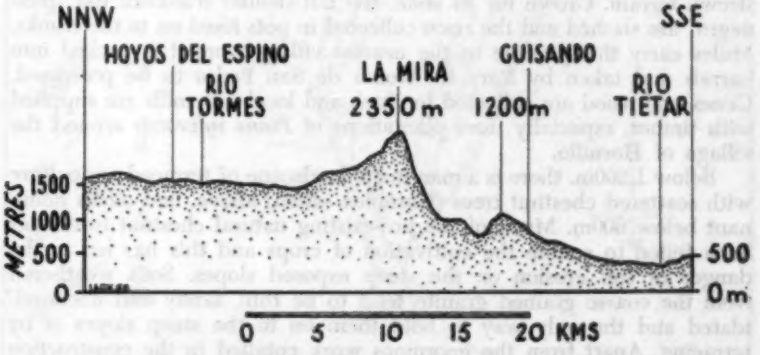


Fig. 2 Cross-section of the Sierra de Gredos [3]

THE ECONOMY OF THE EL ARENAL VALLEY

A detailed study of land use and economic life was made in the El Arenal valley and the adjacent plateau area where a complete range of the altitudinal belts is to be found. This valley is aligned from north to south and is drained by a perennial river, though all but three of

its small tributaries dry up in summer. In places, the hillsides rise abruptly on either side of gorge-like sections, whilst in others, slopes are gentler and there is much low broken hilly ground in the valley bottom. The slopes of the valley sides are concave and are steepest near the summits of the main ridge.

The alpine zone, above 1,600m. presents three facets; a plateau-like area north of the ridge, the main ridge itself and the upper part of the steep southern slopes. The first of these is the most extensive and the most important economically. Snow covered during the winter, its bare treeless expanses are covered in summer with rich pastures, fed by water from the slowly melting snowfields. Here and there on the more favourable lower slopes is a patch of crops, while drier parts usually have a covering of broom *(Cytisus purgans)*. The main use of this facet is for the summer pasturage of large herds of black-horned cattle; flocks of sheep and goats are also pastured here in smaller numbers. Towering above the plateau are lofty frost-shattered peaks and ridges, bare and exposed and devoid of soil and vegetation except for certain alpine plants e.g. *(Jasione* sp.; *Saxifraga* spp.; *Antirrhinum* sp. and lichens). The steep southern slopes consist for the most part of a rocky boulder-strewn scree but there are areas with broom *(Cytisus purgans)* and gorse *(Genista hispanica)* on drier patches and streaks of pasture on wet flushes.

Between 1,600m. and 1,200m. pine forests form a rather sparse but continuous cover dominated by "pino negro" *(Pinus pinaster)* with a few trees of *Pinus sylvestris* (ssp. *nevadensis)* near the upper limit. The shrub and herb layer is poor, represented by *Cytisus* spp.; *Vincetoxium* sp.; *Festuca* sp.; and *Allium* sp.; and there is much bare, sandy, boulder-strewn terrain. Grown for its resin, the tall slender trunks of the "pino negro" are slashed and the resin collected in pots fixed on to the trunks. Mules carry this product to the nearest village were it is packed into barrels and taken by lorry to Arenas de San Pedro to be processed. Cones and wood are collected for fuel, and local saw mills are supplied with timber, especially from plantations of *Pinus sylvestris* around the village of Hornillo.

Below 1,200m. there is a man-made landscape of terraced agriculture with scattered chestnut trees *(Castanea sativa)* above, and olives dominant below 900m. Much of the pre-existing natural chestnut forest has been felled to enable the cultivation of crops and this has led to the danger of soil erosion on the steep exposed slopes. Soils weathered from the coarse grained granite tend to be thin, sandy and unconsolidated and the only way to hold them on to the steep slopes is by terracing. Apart from the enormous work entailed in the construction of the terraces, minute and arduous labour is continually required in the upkeep and repair of the masonry walls.

The extreme summer aridity, poor sandy soils and steep slopes are all factors unfavourable for agriculture. Fortunately, however, the valley possesses a perennial stream fed by snow-melt from which the dry slopes can be irrigated. The irrigation system is well-planned and carefully organised so that every tiny plot is watered regularly. Main ducts are taken off the river at intervals and lead along the hillsides parallel to the contours; from these, subsidiary channels branch off so

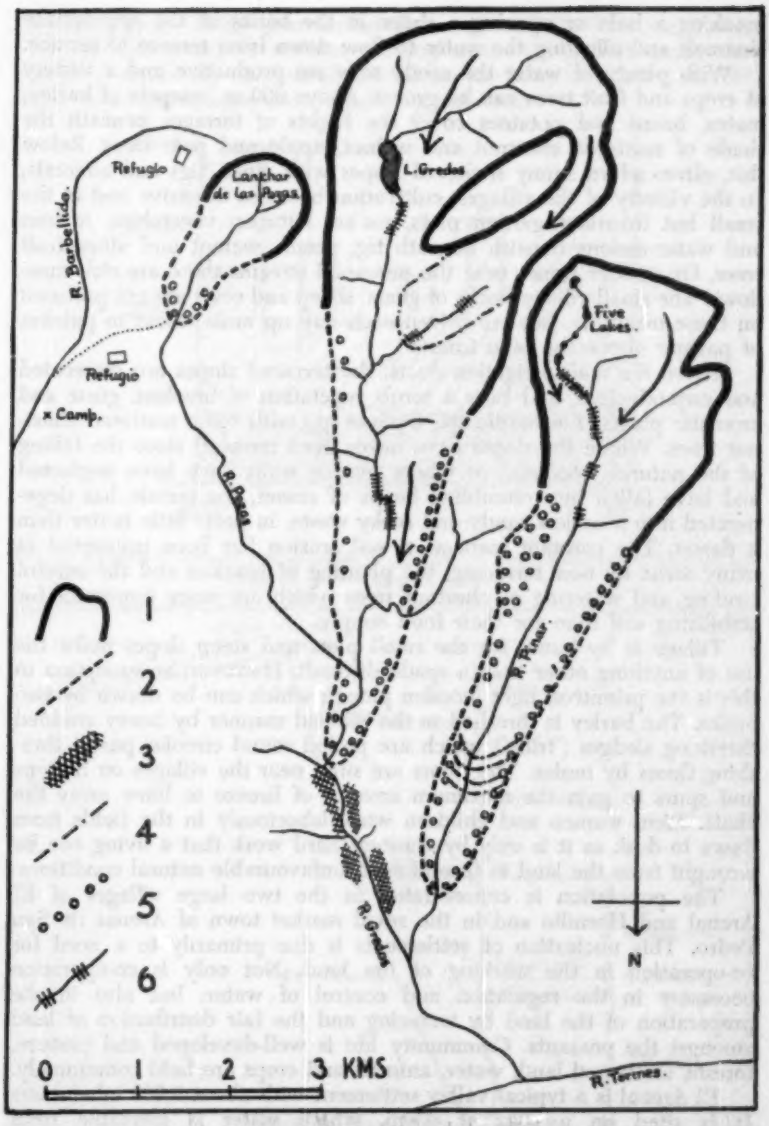


Fig. 3 Major glacial features of the Picos Region.
1. glacial cirques; 2. extent of former tongue glaciers; 3. fluvio-glacial terraces; 4. stages in glacier retreat; 5. morainic deposits; 6. waterfalls.
Modified from : Obermaier and Carandell [3]

that the slopes are covered by a thick network of trenches. At regular intervals of a week to ten days, any particular slope is watered by

breaking a hole or opening a sluice in the banks of the appropriate channels and allowing the water to flow down from terrace to terrace.

With plenty of water the sandy soils are productive and a variety of crops and fruit trees can be grown. Above 900 m., carpets of barley, maize, beans and potatoes cover the flights of terraces beneath the shade of scattered chestnut and walnut, apple and pear trees. Below this, olives adorn sunny sheltered slopes with vines, figs and almonds. In the vicinity of the villages, cultivation becomes intensive and in the small but luxuriant garden plots, maize, lettuces, vegetables, melons and water-melons flourish beneath fig, peach, walnut and other fruit trees. On gentler slopes near the perennial streams there are rich meadows. The small village flocks of goats, sheep and cows are not pastured on these meadows, but are driven each day up mule tracks to patches of pasture above the pine forests.

Above the main irrigation ducts, the terraced slopes are desiccated and unproductive, and bear a scrub vegetation of bracken, gorse and aromatic plants (*Lavendula* sp., *Cytisus* sp.) with some scattered chestnut trees. Where the slopes have never been terraced since the felling of the natural woodland or where terrace walls have been neglected and have fallen into crumbling heaps of stones, the terrain has degenerated into a useless sandy and rocky waste, in parts little better than a desert. The constant menace of soil erosion has been prevented in many areas by new terracing, the planting of bracken and the careful tending and watering of chestnut trees which are more important for stabilising soil than for their food supply.

Tillage is by hand, for the small plots and steep slopes make the use of anything other than a spade difficult. However, an exception to this is the primitive, light wooden plough which can be drawn by two mules. The barley is threshed in the biblical manner by heavy studded threshing sledges ('trillo') which are pulled round circular paved threshing floors by mules. The floors are sited near the villages on hilltops and spurs to gain the maximum amount of breeze to blow away the chaff. Men, women and children work laboriously in the fields from dawn to dusk as it is only by constant hard work that a living can be wrought from the land in face of such unfavourable natural conditions.

The population is concentrated in the two large villages of El Arenal and Hornillo and in the small market town of Arenas de San Pedro. This nucleation of settlements is due primarily to a need for co-operation in the working of the land. Not only is co-operation necessary in the regulation and control of water, but also in the preparation of the land by terracing and the fair distribution of land amongst the peasants. Community life is well-developed and pasture, forests, cultivated land, water, animals and crops are held communally.

El Arenal is a typical valley settlement with about 3,000 inhabitants It is sited on a spur at 900m. where water is available from three small springs. Except on one side where it abuts onto a barren sandy area, (El Arenal = the sandy ground) it is surrounded by intensive polyculture. It is a very compact settlement with a maze of narrow cobbled streets and houses which cluster close to one another. They are built of granite or local brick with a framework of timber, and possess balconies and red-tiled roofs. The ground floor is generally used for

animals and the living quarters are above. (See Pl. 3). The interiors are cramped and primitive without running water, yet paradoxically, they are lit by electricity with which the village has been supplied since 1932 from its own small generator a mile up the river.

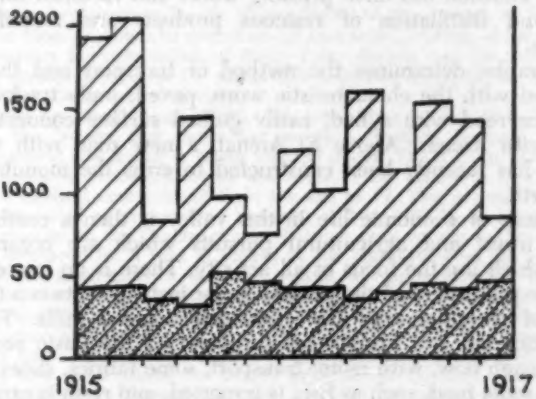


Fig. 4 Graphs of annual precipitation of Arenas de San Pedro (upper graph) and Madrid (lower graph), 1915-27 [5].

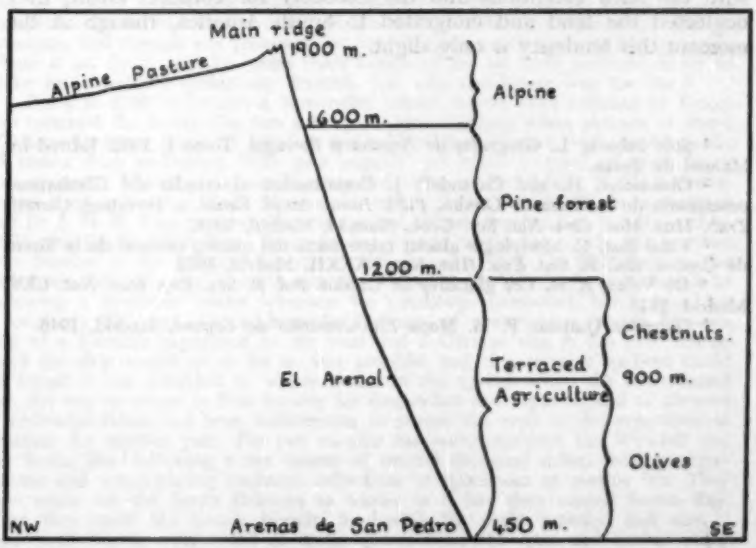


Fig. 5 Diagrammatic cross-section from north-west to south-east to show zonation of vegetation belts in El Arenal valley and adjacent plateau areas.

Arenas de San Pedro is a small market town at the junction of the mountains with the surrounding plain and has about 5,000 inhabitants. It is an old walled-town with a fortress and this historical interest in

addition to its healthy climate attracts several tourists. Only a few tourists penetrate to the higher villages despite their even healthier climate, due to lack of accommodation. The villages and Arenas possess their own flour- and saw-mills (run by electricity) and local brickworks. Arenas in addition has olive pressing works and factories for the purification and distillation of resinous products and manufacture of turpentine.

Topography determines the method of transport and the hillsides are seamed with the characteristic worn, paved, mule tracks. A rather poor motor road with a bad, easily gullied surface connects the two villages with Arenas. Above El Arenal, a new road with very steep gradients has recently been constructed to cross the mountain barrier to the north.

The basis of economic life in this valley is then a combination of pastoral, forest and agricultural pursuits which are organised from villages which are the focus of all activity. There is an interesting mixture of the primitive and the modern as for instance between the ancient method of threshing and the electrically driven mills. The village communities are still largely self-sufficient in the basic requirements of life, though now, with motor transport, some fabrics, shoes, hardware and even some food, such as fish, is imported, and resin is exported. The peasants are maintained on a low but adequate standard of living by their constant hard work. In the past, when they became discouraged with the hard conditions and the necessity for constant effort, they neglected the land and emigrated to South America, though at the moment this tendency is only slight.

[1] Sole Sabaris, L. *Geografia de Espana y Portugal.* Tome I, 1952. Edited by Manuel de Teran.

[2] Obermaier, H. and Carandell, J. Contribucion al estudio del Glaciarismo cuaternario de la Sierra de Gredos. *Publ. Junta. Ampl. Estud. e. Investing. Cientif. Trab. Mus. Mac. Gen. Nat. Ser. Geol.*, Num.14, Madrid, 1916.

[3] Vidal Box, C. Morfologia glaciar cuaternaria del macizo oriental de la Sierra de Gredos. *Bol. R. Soc. Esp. Hist. Nat.* t.XXXII, Madrid, 1932.

[4] De Villar, E. H. Los glaciares de Gredos. *Bol. R. Soc. Esp. Hist. Nat.* t.XV, Madrid, 1915.

[5] Gonzalez Quijano, P. M. *Mapa Pluviometrico de Espana,* Madrid, 1946.

TRANS-ANTARCTICA – FROM BRUCE TO FUCHS

DOUGLAS A. ALLAN

The inspiring lecture given by Sir Vivian Fuchs to the Society in Edinburgh and Glasgow in June, at which he described his successful crossing of the Antarctic continent, represents the culmination of South Polar exploits and the realisation of a South Polar project, which has for nearly half-a-century engaged the interest of the Royal Scottish Geographical Society.

At a lecture on 22nd March, 1900, Sir John Murray, our then President, announced to the Society that there was to be a Scottish National Antarctic Expedition, organised and led by a young medical doctor. Dr William Spiers Bruce was born in London of Scottish forbears, and came to the University of Edinburgh to embark on a medical course in 1885, at the age of 17. The normal career of a medical graduate failed to attract him, however, and in 1902 he took the post of surgeon and naturalist on the Dundee whaler *Balaena*, on a voyage to the Antarctic. On his return he served for a year in charge of the observatory on the summit of Ben Nevis, but the fascination of the Polar wastes was upon him and from 1896 to 1899 he sailed the Arctic in various whalers. This let him see enough to realise the immense scientific results in almost every field waiting to be garnered at the poles, and he wanted to break away from the part-time scientific surveys, fitted in between the more economically important tasks of whaling, to a wholly scientific expedition free to go where the results promised to be most profitable. He aimed to raise funds for a Scottish National Antarctic Expedition to work to the south of Cape Horn, exploring the Weddell Sea, so named from Captain James Weddell who sailed into it in 1823, in the brig *Jane* from Leith. Despite the leader's dauntless perseverance and tireless enthusiasm in the face of great difficulties — and he worked largely single-handed — money for the projected expedition was slow to come in, and it was not until November, 1901, that Bruce was able to announce that enough was promised for one complete year's work in the Antarctic. There is no doubt that his plans were hampered by his ultra patriotic desire to make his expedition exclusively Scottish, but who can blame him for that?

Early in 1902 he bought a Norwegian whaler which, after refitting at Troon, was renamed the *Scotia*. She was a barque-rigged auxiliary screw steamer of about 400 tons, having a length of 140 feet and a breadth of 29 feet, with wooden walls 25 inches thick amidships. With new engines and boiler a speed of seven knots was expected. The Captain was Thomas Robertson of Peterhead; R. N. Rudmose Brown went as botanist, R. C. Mossman as meteorologist, D. W. Wilson as zoologist and Dr J. H. H. Pirie as geologist and medical officer. On Sunday, 2nd November, 1902, the *Scotia* sailed from Troon on her voyage to the far south. She reached Port Stanley, in the Falkland Islands, on 6th January, 1903. On 25th January, the expedition left, steering a south-easterly course to the Weddell Sea, aiming at following a southerly course wherever ice conditions permitted, before reaching a longitude 30° west. Bruce chose for his area of operations a region between that of a Swedish expedition to the west and a German one to the east. Southward the ship would go as far as was possible, and if a suitable harbour could be found it was intended to winter there. In the spring, when the ice released her, she was to return to Port Stanley for despatches and supplies, and to discover if additional funds had been forthcoming to permit the work of the expedition to continue for another year. For two months the party explored the Weddell and the Scotia Sea, following a sea course of several thousand miles, making observations and accumulating immense collections of specimens of marine life. They then made for the South Orkneys to winter in a bay they named Scotia Bay. Here they used the *Scotia* herself, ice-bound for eight months, and also a shore-built house, constructed of stone quarried on the spot and timber taken from the ship. The inhabitants devoted their time to meteorological, magnetic and biological work, with ski-ing for exercise, but were glad when, after 240 days, the breaking ice freed the *Scotia* in late November to return to the Falkland Islands and to Buenos Aires. Disappointment awaited them, alas, and they had to remain there in considerable anxiety — hoping for more funds, and to get the necessary supplies and stores for the second stage.

Leaving on 21st January, 1904, the *Scotia* was back in the South Orkneys on

1st February and, after a week's preparation, set out again southward into the Weddell Sea. This season, luck was with them and, in contrast to the previous year, they met at first very little pack ice, and pressing south beyond Ross's furthest south in 1843, reached at length an impenetrable barrier of ice, fringing the unknown Antarctic continent. Part of it consisted of ice cliffs ranging from 100 to 150 feet in height above the sea, elsewhere it sloped gently down, presenting an impressive ice coast-line of frowning headlands alternating with gentler hollows, while inland there appeared to be ranges of high mountain. This new discovery was named Coats Land, in honour of the most generous supporter of the expedition. In their anxiety to see more of this new land, they took risks with the pack-ice, and got firmly caught early in March, but fortunately on the sixth day lanes opened and the expedition, ill-equiped to face an Antarctic winter frozen in the Weddell Sea, headed northwards for home. On 21st July, 1904, they received an enthusiastic welcome off Arran, by the President of the Royal Scottish Geographical Society and a large body of supporters. H.M. The King sent a telegram of congratulation and Dr Bruce was awarded the Gold Medal of the Royal Scottish Geographical Society.

This strikingly succesful expedition, which involved two summers in the Weddell Sea and the intervening winter in the South Orkneys, not only discovered 150 miles of unknown coast-line but conducted immensely valuable hydrographical and biological surveys, down to depths of 3,000 fathoms, and made collections, which in variety and extent have probably never been equalled except by the *Challenger*. The Meteorological Observatory built at Scotia Bay was taken over by the Argentine Government and subsequently maintained by them. Yet the whole expedition cost only some £35,000.

The success of his expedition whetted Bruce's appetite and, at a meeting of the Royal Scottish Geographical Society held in Edinburgh on 17th March, 1910, he outlined his plans for a new Scottish Antarctic Expedition for 1911, with as its major aim the first projected traverse of the Antarctic continent from Coats Land to the Ross Sea. It was hoped that the expedition would leave Scotland about 1st May, 1911 and reach Buenos Aires about 20th June. From Buenos Aires the ship was to sail about 1st July and follow a zigzag course between 40° S. and 50° S. for the purpose of broadly completing the bathymetrical survey of the South Atlantic begun by the *Scotia*. Cape Town was to be reached on 1st September and after coaling and refitting, she was to make for the Sandwich Islands, where it was hoped that funds would permit another vessel to meet her carrying equipment, coal and fresh food from Buenos Aires. The expedition was then to head for Coats Land or some suitable place with anchorage and landing, either to the east or to the west of that inhospitable coast. There a party of 10 to 12 would be landed and a house built. The ship was to proceed to Melbourne, undertaking further survey operations on the way in as high latitudes as possible, and winter in that port, carrying out such research work as funds permitted and co-operating with the Australian and New Zealand governments. In the spring, she was to push southward to McMurdo Strait, Victoria Land, where a sledge party was to be put ashore to meet another one, probably of four men, led by Bruce himself, which was to cross the Antarctic continent from the Weddell Sea by way of the South Pole, the journey being made along the meridian of Greenwich on the Atlantic side and continuing along the 180° meridian on the Pacific side. Following the example of Shackleton, who pioneered the use of motor-power in South Polar exploration, it was proposed to employ it in this new expedition. The projected meeting place was to be in the vicinity of the Beardmore Glacier. The combined parties would proceed to the ship in McMurdo Strait and sail for New Zealand. From there the expedition would traverse the Pacific Ocean to Magellan Straits or the Falkland Islands, carrying on oceanographical research in high latitudes. In the spring, she would return to the Weddell Sea to relieve the wintering party, after their two years sojourn there. The total cost of the expedition was estimated to be about £50,000.... For lack of funds, the project was abandoned. The war came and after it Bruce led two expeditions to the Arctic — to Spitsbergen. He died in 1921, denied the chance to fly his St. Andrew's cross again beneath the Southern Cross.

A variety of expeditions from many countries explored and mapped the fringe of the Antarctic continent, found to be almost as large as Australia and Europe together, but of the great central mass there was known only that little derived

from the heroic journeys of Shackleton in his attempt to reach the South Pole in 1909 and of Amundsen and Scott, who succeeded in 1911-1912 — the first and the third of these up the east side of the Ross Sea and the second up the west. The geology, the geography and the biology of a whole continent remained practically unknown. Was there one land mass or were there two? Did the Andean Chain continue through Graham Land into the continent and cross is? What were the structures and the mineral wealth concealed beneath thick ice sheets and how thick was the ice? All these and more were the problems, the prizes that awaited imaginative exploration, carefully planned and adequately equipped. Shackleton with his Imperial Trans-Antarctic Expedition of 1914 planned to start from a base in the Weddell Sea, to make the South Pole and proceed to a base set up in the Ross Sea area, from which a party would lay depots of food and equipment for the Polar Crossing Party. His ship, the *Endurance*, got far south in the Weddell Sea in 1915, but became caught in the ice, drifted west and was eventually crushed. The men were relieved after their leader's exploit in reaching South Georgia for help.

A legacy of world-wide power, of the need for naval harbours, of the importance of meteorological data and systematic marine biological observations had left the British Empire with important outposts in the southern seas, among them groups of islands based for administrative purposes on the Falkland Islands and known as the Falkland Islands Dependencies. To the Leadership of the Falkland Islands Dependencies Survey in 1947 there was appointed a Cambridge graduate, Vivian Ernest Fuchs, thirty-nine years of age, a geologist, who had won his spurs in East Greenland. An enthusiastic and experienced explorer, he was, in 1950, promoted to be Director of the Dependencies' Scientific Bureau. Just prior to that, in December, 1949, confined to their tent in a blizzard in Alexander Land, nearly 500 miles from their base, Fuchs outlined to his companion a scheme to cross the Antarctic from the Dependencies via the South Pole to the Ross Sea. Bruce's plan was reborn. It would require bases at both sides of the continent, aircraft for reconnaisance over land and sea, mechanical transport and the traditional dog teams.... and it would demand much money — perhaps a quarter of a million pounds! Fuchs mooted his project when he got home in 1950, but it was not until 1955 that he was asked to produce plans for a journey across the Antarctic, and early that year a General Committee was formed to further the project, of which Fuchs was right away seconded as leader. Three subcommittees were appointed to deal with finance, the scientific programme and the selection of personnel. On the 17th February, Sir Winston Churchill announced that her Majesty's Government was making a grant of £100,000 towards the project, and further financial and other support was soon forthcoming from New Zealand, South Africa and Australia. Together the Commonwealth Governments contributed a cash sum of £187,000, leaving over £500,000 to be found from other sources. Industries, Trusts and Societies generously rallied to the cause, and even the schools played a valiant and valuable part. Offers of volunteers poured in and the organisers had a difficult task in the final selection of a representative Commonwealth of men of character and physique, with the required specialist knowledge and experience, on whose grit and forbearance so much of the success of the expedition would surely depend. The first to arrive was 28 years old David Stratton, surveyor with the Falkland Islands Dependencies, who was to become the second-in-command. The others followed and soon a goodly company were at work, planning the details of the expedition, finding and checking the equipment and preparing for their various parts. In New Zealand, another committee was similarly engaged on securing the men, under Sir Edmund Hillary, and the materials for the Ross Sea enterprise. The Royal Air Force and the Royal New Zealand Air Force both lent invaluable aid in their respective zones, and added useful assistants to the ground parties.

The Advance Party, which sailed south on the M.V. *Theron* on the 14th November, 1955, consisted of eight men, and had as its task the setting up of the main base as far south as possible in the Weddell Sea. There was the possibility of sharing the Royal Society's International Geophysical Year base at Halley Bay, but this was rather far north and separated from the main route to the pole by difficult ice. With good luck and determination, and the aid of Auster aircraft reconnaisance, the *Theron* negotiated narrow sea lanes, with grave risks of being caught like others in the same area, and eventually reached Vahsel Bay, the

leader's goal. Across the sea-ice on a rising shelf was set up Shackleton Base, and the work began. In November, 1956, the Trans-Polar Party of twelve left Britain on the M.V. *Magga Dan* and duly made Shackleton Base. The Royal Air Force contingent helping them numbered four. Meanwhile, from New Zealand, the Ross Sea Party sailed on H.M.N.Z.S. *Endeavour* to McMurdo Sound and set up the Scott Base, not far from an American one. With the New Zealand party of fifteen were three members of the Royal New Zealand Air Force and also five members of the New Zealand I.G.Y. party. At each base preparations had to be made for the trans-continental project and for scientific surveys in the two areas. Some 300 miles inland from Shackleton Base on the route to the pole, the Main Party set up an advanced camp, called South Ice. From Scott Base, the New Zealand party effected reconnaisance surveys and, following what seemed to be the most practicable route, set up Depot 700 to help the main Trans-Polar Party on the homeward section of their journey. The meeting of Fuchs and Hillary was planned to take place in the vicinity of Mount Albert Markham, approximately 500 miles from the Pole — not far from Bruce's projected Beardmore Glacier meeting of nearly half a century before. At the South Pole itself, there was on this later occasion, the important I.G.Y. camp of the United States of America, air- delivered and air- supplied, and appropriately entiled "Little America". The two base parties undertook their respective programmes of work in cartography, geology, glaciology, biology, physiology and meteorology, and it will be some considerable time before these results can be analysed, interpreted and published. That they will be of great importance is already sure.

The Trans-Polar Party, of twelve men, of whom Fuchs was the leader, with Weasels, Sno-cats and a Muskeg tractor, set out from Shackleton Base at 6.40 a.m. on the 25th November, 1957. Two dog teams went on ahead. After many adventures with enormous crevasses, in which vehicles were nearly lost, the South Pole was successfully reached on the 19th January, 1958, and there the meeting between Fuchs and Hillary took place, against the enthusiastic background of an American welcome for, having completed his alloted task of preparing Depot 700 Hillary pushed pluckily on to the Pole, with 4 companions on 3 tractors reaching it on 4th January. After an equally welcome rest, Fuchs and his Sno-cats set off on the 24th January, precisely two months after leaving Shackleton. They were not yet half way, for they had done 900 miles and had 1,250 miles still to go to Scott Base, but they were on the route so well-surveyed and supplied by Hillary and his party. They had two major anxieties — the Antarctic's variety of pea soup fog, known as "White-out", and the risk of an early freeze-up in McMurdo Sound, which might force the New Zealand ship to leave them to another winter in the wastes. But, despite accidents to both men and machines, the party safely reached Scott Base at three minutes to two on 2nd March, 1958. The first land crossing had been successfully accomplished, and by a British Commonwealth Expedition. They had travelled 2,158 miles in 98 days — two days ahead of schedule — and had demonstrated the ability of man and of man-made mechanisms such as tractors and aeroplanes to stand up to the severe tests of Antarctic conditions. Another pioneer crossing was that of 4 men in a single-engined Otter aircraft, who flew direct from South ice over the Pole to Scott Base covering 1,430 miles in 11 hours. The younger generation of scientists and explorers, undoubtedly aided by the advances of modern science, medicine and technology, had again demonstrated how very much depends upon human grit, ingenuity, endurance and will power. Nor in their success did they forget their predecessors, for in his book Fuchs writes of the South Pole celebration party.... "We also unfurled the flag of the Scottish National Antarctic Expedition 1901-03, which had been taken by William Spiers Bruce on his voyage in the *Scotia*, when he discovered Coats Land on the east side of the Weddell Sea. This had been handed to me in Edinburgh by the President of the Royal Scottish Geographical Society with the request that we should carry it with us to Coats Land and on across the continent. Another item of interest was Captain Scott's watch which I had worn on a leather thong round my neck since starting on the journey. This had been.... entrusted to me to take back to the South Pole and on to Scott Base". His charges faithfully carried out, Sir Vivian Fuchs, before an enthusiastic audience of over 2,500 in the Usher Hall, Edinburgh, and accompanied by David Stratton, received the Gold Medal of the Royal Scottish Geographical Society and handed back to its President the Saltire cross of Bruce of the *Scotia*.

GEOGRAPHY AT THE BRITISH ASSOCIATION

The British Association for the Advancement of Science provided Glasgow, from the 27th of August to the 3rd of September, with an attraction which could compete with those more regular delights of 'The Glorious Twelvth', 'The Royal and Ancient' or 'The Festival'. The response was not however as great as might have been expected from a region which harbours some two million people within a twenty-mile radius of the University and which produced so many of the early pioneers in science and technology.

More than a hundred geographers attended Section E and included such distinguished overseas visitors as Professors Pierre Camu (Quebec), Chapman (Vancouver), Macar (Liège) and Tore Sund (Bergen) and Mr Kubiatowicz (Warsaw). Nevertheless many Scottish geography teachers must have regretted that the meeting occurred after the start of the school term and that they were unable to attend. Certainly, ample opportunity to know 'your' or to discover 'our' region was provided in the preliminary suite of papers on aspects of Glasgow presented by Professor R. Miller, Mr H. A. Moisley and Mr D. Diamond. These were richly supplemented by exhibitions of maps, diagrams and photographs in the Geography Department and by a wide variety of excursions within and far beyond the city.

It was perhaps fitting that, in a city which has been described as "the largest Irish city in the Eastern Hemisphere". Professor Estyn Evans of The Queen's University, Belfast, should preside over Section E and that in his Presidential Address on 'The Atlantic Ends of Europe' he should bewitch us with his own inimitable brand of celtic magic. With superb craftsmanship, he selected the relevant strands and wove the cultural pattern which binds the remote, detached, isolated western outposts of Europe, from the north coast of Spain to the far Lofoten Islands, into a distinct and distinctive human region. The Celtic theme was taken up again in a joint session between Section E and H (Anthropology and Archaeology) on 'Rural Settlement' under the distinguished and stimulating chairmanship of Professor H. J. Fleure. Papers by Dr H. Fairhurst *(Glasgow)*, Dr V. B. Proudfoot *(Belfast)*, Mr Glanville Jones *(Leeds)* and Dr W. Ravenhill *(Exeter)* considered some of the problems related to the early evolution of settlement types in Western Scotland, Ireland, Wales and South West England respectively.

The two other suites of related papers dealt with aspects of Scottish geography: water resources and needs, and early geographers and geographical surveys in this country. In the first, papers by Dr R. Maclagan Gorrie *(R.S.G.S.)* on the need for river-flow studies, by Mr P. O. Wolf *(Imperial Coll.)* on the techniques and devices used in river-flow and flood measurements and by Mr. F. H. W. Green *(Nature Conservancy)* on evaporation and land use in water conservation studies, made it all too obvious how little is really known about our water resources — a serious situation in view of the pressing demands from H.E.P. installations and industry indicated by Mr P. L. Aitken *(N. Scot. Hydro Board)* and Mr L. B. Aitken *(Scottish Council)*.

In the second suite of Scottish papers we were delighted and fascinated by Professor A. Steven's brilliant lecture on the state of geography and its place in the curricula of the medieval Scottish Universities. This was followed by a description of some of the early geographical surveys of Scotland — those of Macfarlane in the seventeenth and early eighteenth centuries, by Mr F. V. Emery *(Oxford)*, and of the later *Old* and *New Statistical Accounts* by Dr A. Geddes *(Edinburgh)*; in the discussion that followed Mr A. M. Struthers of the Scottish Council of Social Services outlined the progress in the current production of the *Third Statistical Account*.

In addition there was a wealth of other papers on diverse topics and it must be regretted that the space here is as inadequate as was the time during the meeting to give them serious consideration. They included: the use of tree rings in climate chronology by Mr D. J. Schove *(St. David's Coll.)*; a re-examination of Gradmann's steppe-heath theory by Dr Karl Sinnhuber *(U.C.L.)*; changing regional advantages in the Bukoba districts of Tanganyika by Mr D. N. McMaster *(Makerere)*; the ports of West Africa by Mr H. P. White *(Fourah Bay Coll.)*; the pattern of services in North East England by Mr B. Fullerton *(Durham)* and the geographical distribution of professional persons by Drs R. H. Osborne and

R. J. Jones *(Edinburgh)* The meeting concluded with two interesting Scottish regional studies — of Kintyre by Mr L. Symons *(Belfast)* and of Islay by Miss Margaret Storrie *(Glasgow)* — two regions of exceptional agricultural prosperity in Highland Scotland.

While there is little doubt that the rapidly spreading and dividing branches of geography flourished exceedingly at this meeting of the British Association — one might venture to suggest that they were, in fact, in danger of becoming rampant — the proliferation of leaves (albeit of paper) was such that the fruits of discussion rarely had a change to set. J. T.

JOHN ALLAN BROWN

The recent and sudden death of John Allan Brown has deprived the Royal Scottish Geographical Society not only of its most efficient Honorary Treasurer and of an active member in all its spheres but of a valued friend.

Mr Brown accepted the invitation to become the Honorary Treasurer to the Society in 1952, to which voluntary rôle he brought a considerable knowledge and experience of financial matters. His outstandingly successful and distinguished career as a banker with the National Bank of Scotland, started in 1905, culminated in his appointment as General Manager in 1947. From 1935 onwards he was a member of the Council of the Institute of Bankers and its President from 1947-1949.

His work however ranged far beyond his official banking duties. During the war he established and maintained contact with prisoners of war from all banks, providing them opportunities for study and advancement. Also he did much to further interest in and gain support for the Bank Clerk's Orphanage as well as conceiving the idea of a Staff Benevolent Fund. Nor were his interests limited to his own professional field; he worked assiduously but unobtrusively for the cause of the blind, as Convenor of the Blind School and of the Braille Press and as a member of the Board of the Blind Asylum and Linburn. He was indeed a public servant in the highest sense of the word.

To the Council of the Royal Scottish Geographical Society he brought the same sense of vocation and conviction and became at once a clear-sighted and invaluable financial advisor and administrator and a warmly appreciated personality. As President, I cannot speak too highly of his services to the Society, of his wise handling of our financial problems and of his kindly interests in new projects yet firm hand on expenditure. He and his car were always available at the little dinner parties before the main lectures and provided a welcome convoy to the Usher Hall, a compliment greatly appreciated by visiting lecturers. He enjoyed the Council Meetings and all opportunities of meeting and getting to known members. The Summer Tours provided further opportunities for his good neighbourliness, and for the colour photography in which he revelled and at which he was so undeniably a master. In his later years this hobby gave him a new interest and outlet for his energies, perhaps as a natural relief from office work, he loved to be out of doors, indulging in hill walking, fishing or bowling.

Yet in all his activities, official as well as unofficial, he was ever kindly and retiring, the last person to publicise his own efforts or contributions. The Society, at all levels, will miss him in more ways than one.

Douglas A. Allan

THE CULTURAL LANDSCAPE OF CELTIC COUNTRIES
A REVIEW

E. ESTYN EVANS

Dr Pierre Flatrès of the University of Rennes has worked with immense zest on his chosen subject, the rural geography of the Celtic lands [1], and he brings to it not only a long training in the humanist traditions of French geography but close familiarity with Celtic languages and customs and with the Breton scene which he uses as a yard-stick in his work on the British Isles. That he should have excluded Scotland from his studies is a matter for regret, but astonishment at what he has achieved must be our main reaction on reading this large volume. After all, compared with Ireland, Wales, Cornwall and Man, the rural geography of Scotland is relatively well-documented, and one would prefer to see these studies extended, as the author himself admits, to north-western England.

The book has 618 pages and several loose maps. There are some fuzzy half-tones and over 60 maps and diagrams in the text, but the maps are poorly executed and sometimes so badly printed as to be illegible. Altogether this is a typical French production, often brilliant, packed with ideas, but badly arranged, loosely constructed and so loosely bound that my copy almost disintegrated before I had reached the bibliography. This has nearly 900 entries, and though marred by a few omissions and some misprints is in itself a very valuable contribution.

Extensive fieldwork, studies of large-scale maps, wide reading and enquiries into local tradition: these are the four legs on which Dr Flatrès stands to survey his field of study. In accessing the influences of the physical background he lays most stress on the Atlantic climate, its clouds, mist, storms, high winds, equable temperatures and well-distributed rainfall. Yet he sees that the lush green swards which now support an intensive pastoral husbandry are of no great antiquity, and he is faced with the paradox that in climates so unsuited to cereal cultivation the traditional system was one of continuous cropping to the point of soil exhaustion. The morphology of the four regions is discussed and mapped, rather as a pious duty than from conviction as to its relevance. Topography and soils are of course limiting factors — though fields are made on bare rocks in the Aran Islands — but the conclusion reached is that the cultural patterns of field and farmstead extend over wide areas with very little reference to geology or morphology. Some attention is devoted to glacial landforms such as drumlins, but again it is found that both settlements and field-systems differ from one drumlin area to another.

History, therefore, must provide the key, though space-relations are all-important since that history can be understood only in the light of the position of the Celtic fringe. From one point of view it is the Atlantic end of Europe, from another a maritime highway leading from the Mediterranean. History must also include prehistory, for agricultural origins are prehistoric. The field patterns of the present-day, to which Dr Flatrès devotes so much attention, are admittedly mainly the outcome of the agrarian revolution and of the landlordism of the eighteenth and nineteenth centuries, but the scale of the pattern and the basic system of agriculture are far older. In the end he is led to the view that the essentials of the "Atlantic rural system" derive from north-western Spain.

In his discussion of landlordism he has missed the important paper by L. R. Palmer (*Achaeans and Indo-Europeans*, [1955]) in which it is argued on philological grounds that the dichotomy of a warrior hierarchy holding land individually and a ground mass of cultivators practising open-field agriculture is as old as the Neolithic period and that both are fundamental Indo-European institutions.

The infield which gives its name to the traditional Scottish system finds parallels in Brittany and Cornwall, but I doubt whether the author is right in considering its distribution in Ireland to be confined to areas planted from Scotland. The important point, however, is that infield and outfield represent different degrees of intensity of continuous cultivation, and that both were part of a social and economic system which was widely distributed along the Atlantic fringe. In terms of settlement it was represented by clusters of habitations to which Flatrès, for want of a better term, applies the word village. He is thus obliged to use the term "communal village" for the manorial village of the English Lowlands, but the "clachan" — as it is termed in Ulster — was a much more closely knit

community than the English village. Essential features of the Atlantic system were the insistence on equal shares of the land and on equivalent rights in the use of the waste. Transhumance is also a characteristic concomitant.

The author's analysis of the sizes and shapes of enclosures and fences represents an overwhelming amount of work, and it is doubtful whether features so subject to personal and local idiosyncrasies are really amenable to statistical study. Nevertheless some interesting conclusions emerge, and local study of selected areas would probably be rewarding. The fields are found to fall into six types, named by their shapes: irregular, strip-fields, regular (large), regular (small and medium), ribboned and open-fields. The ribboned fields are really a special case of the small regular class: they are the 'striped' farms or, as I prefer to call them, ladder farms, favoured by the Congested Districts Board in Ireland. Open-fields are now rare, and it must be admitted that Dr Flatrès makes rather too much of them as survivals, but not infrequently the clustered settlements which went with them have survived. The strip-fields are fossilised plough strips of manorial open-fields and their present distribution is largely, if not entirely, explained on historical evidence. The areas where large regular fields prodominate are the lowland areas favoured for landlords' residences, and Dr Flatrès finds that the most favoured shape is a rectangle with the longer sides half as long again as the shorter. This proportion holds also for the majority of small and medium regular fields and is believed to show the influence of landlordism. Not unnaturally irregular fields are most abundant in country showing many rock outcrops and frequent erratics, but areas of recent piecemeal enclosure from the waste also show a high "index of irregularity". Although in most instances the field patterns discussed — with exception of the open-fields — can be shown to date from recent centuries, there are hints that some of them may, in certain localities, be of prehistoric origin. However this may be, permanent enclosure on any scale is on the whole a recent feature of Celtic lands. Equally, the even scatter of farmsteads is the product of changes that took place between the sixteenth and the nineteenth centuries.

Dr Flatrès proposes a new division of the Celtic lands which cuts across the linguistic division as between Goidelic and Brythonic. Scotland he places with Man, north of Ireland and the northern half of Wales as forming a "tribal, bardic and pastoral" world: the rest — south Wales, Cornwall and Brittany — he describes as non-tribal, without bardic literature and with little pastoralism but devoting more atention to cultivation. He goes on to point the contrast between the "poetic pastoral people" of the northern province and the more materialistic peasants of Cornwall and Brittany, and hints that this contrast has been the cause of much misunderstanding among the peoples of the Atlantic fringe.

What is the most likely contribution which Scotland can make to the subject in its large setting? Here is one suggestion. In Ireland we need to known what conditions prevailed in the various areas from which colonists were derived in the seventeenth century. This really means delving in a period for which little documentary evidence exists, and I use the word delving deliberately. Excavation of abandoned clachans in Ulster is producing promising results. May we hope that similar efforts will be made in Scotland?

It is impossible in a short notice to do justice to the many other topics discussed in this exciting book. Its appearance will certainly stimulate workers in the British Isles, but they will not always confirm its findings in detail. For Dr Flatrès concludes that adaptability and flexibility are outstanding characteristics of the rural Atlantic world.

[1] Pierre Flatrès. *Géographie rurale de quatre contrées Celtique : Irelande, Galles, Cornwall et Man.* $9^3/_4 \times 6^1/_2$. Pp.618. 10 plates. 61 figs. 3 end maps. Librairie Universitaire J. Plihon, Rennes, 1957.

THE HUMAN GEOGRAPHY OF THE OUTER HEBRIDES
A REVIEW

JAMES B. CAIRD

In 1956, Dr Jaatinen, of the Department of Geography, University of Helsinki, visited the Outer Hebrides. *The Human Geography of the Outer Hebrides* [1], with special reference to latest trends in land use is the remarkable outcome of his short visit. Dr Jaatinen offers his study as a contribution to island geography, and it is an excellent characterisation of the geography of the different sub-regions of the Outer Hebrides, based on thorough study of the literature, with some detailed studies of sample crofts. During his stay, Dr Jaatinen lived with the crofters *en famille*, and it is obvious from his writing that he understands the Outer Hebridean crofter, for purely statistical studies fail to touch on the essential problems of the crofting way of life. From a foreign visitor and specially from a Scandinavian we expect a different perspective and we are not disappointed: refreshingly, the study is free of prejudice.

Dr Jaatinen's study is divided into six sections: The Pattern of the Islands; The Fabric of the Economy; Designs for Living; A suggested Regional Division of the Outer Hebrides; Conclusions; Archipelagoes in Comparison — The Outer Hebrides and the Aaland Islands. There is also an excellent bibliography of some 90 items.

In the section on "The Pattern of Islands", Dr Jaatinen describes the space relationships and the physical environment, and painstakingly reviews the literature, ensuring the ommission of nothing relevant to the inter-relationships.

Having set the scene, he goes on in "The Fabric of the Economy" to describe the evolution of the crofting landscape illustrating his theme with some very well-chosen quotations from the earlier writings — a useful feature throughout the study. His chapter on population of necessity leans heavily on published statistics and general impressions. This highlights a major problem of geographers working in the crofting area: parish statistics are inadequate for crofting studies: statistics both of population and agriculture are required on township level. Dr Jaatinen mentions the mobility of the working population, indeed the true population of a crofting township may be calculated as those wholly resident, seasonal migrants, and those permanently working away from the township and parish. The Census takes no cognisance of the latter category: this explains the low proportion of the 15-44 age groups as compared with the Scottish average. Thus the population of most crofting townships is partly resident and partly absentee, and unfortunately for the efficiency of crofting, the absentees are in the main in the younger working age groups.

In describing the crofting economy, Dr Jaatinen questions the numbers and size of crofts as given in the West Highland Survey, pointing out that there are cases where more than one family live on a croft — cottars in addition to the legal tenant. He might also have mentioned the crofts in the hands of absentee tenants or elderly tenants too old to work their crofts which are often sub-let, so that many a crofting township has fewer actual operative units than the number of legal crofts. The pattern of croft layout in many townships is one of a new fragmentation of operative units — the parent croft and sublets or acquired crofts. It is only by a croft-by-croft study that the actual operative units can be determined. On the general question of sub-letting (p.43-44), one cannot always agree with Dr Jaatinen, for although this practice ensures some use being made of the croft, it is nearly always in the form of grazing: the lack of security of tenure inevitably discourages investment in the form of capital or labour. In townships where many crofts are sub-let, an organised redistribution of the croft land would make for stability in the form of larger, more economic units.

Dr Jaatinen's studies in the Aaland Islands provide a useful basis for comparison in land tenure and land utilisation. Although, as he points out, the situation of the Aaland Islands on the route from South-west Finland to Stockholm, is more favourable than that of the Outer Hebrides, more initiative and ingenuity prevails in the Aalands. This may arise because of the owner-occupier status of landholding in the Aalands, but Dr Jaatinen rightly feels that a great deal more could be done in the way of market gardening and pasture improvement in the Outer Hebrides.

Summarising the economy, Dr Jaatinen has this to say: "Crofting is not considered an end in itself, worth the whole endeavours of the family, or better still of the township, to improve it.... Instead, the farm work is seen as just part of the home on the croft". This is certainly true for the great majority of Hebridean crofts: partly because of their small size and partly because such props as fishing, which in the past formed a livelihood, have been removed from the economy. Most of the younger members of the families are forced by lack of ancillary employment to leave the townships: the "standard of spending" on a croft cannot compete with work in the city. But the land is often considered secondary to local employment also so that a minority of the working population are now full-time crofters (7 per cent in Barra, 23 cent in South Uist)[2]. Two distinct crofting populations have developed — those who want to croft full-time, and those who want to retain the advantages of crofting status but follow other employment. With a proportion of the crofters engaged in full-time ancillary employment and others absent for most of the year in employment elsewhere wholehearted co-operation in a crofting community is rare. (In a Lewis township in 1958, only twelve crofters out of a total of 58 participated in a township re-seeding scheme, costing only £1 (one pound) per head and their labour). If crofting is to be stablised, more opportunity will have to be given to the keen crofter.

"Design for Living" (pps.59-81) is quite the best of Dr Jaatinen's work. Here nine sample crofts are described in detail, with an excellent layout and land use diagram for each. Royal Air Force air photographs at the end of the book are carefully integrated into the text. Dr Jaatinen's conclusions are interesting and valid. He recognises the need for change to larger units and the desirability in the absence of industry of a further reduction in the population. At the same time he appreciates the dangers of radical change on the crofting society. He makes a plea for cash crops — in the form of hay, potatoes and vegetables, for more local fishing and for tourism. He points out that 30,000-40,000 tourists come to the Aaland Islands and that many of them do not wish a high standard of comfort involving great capital outlays on the part of the tourist industry.

Dr Jaatinen's study is an excellent summary of the elements and factors which go to make up the human geography of the Outer Hebrides. He recognises (in his preface) that much detailed work remains to be done. Since the summer of his visit (1956) staff and students of the Department of Geography of the University of Glasgow with financial support from the Carnegie and Soddy Trusts, have been making such detailed studies of crofting areas, in Barra, South Uist, Harris, Lewis, and Skye, with the object of defining crofting in this day and age. Land use, crops, stock and population (including seasonal and permanent migration) have already been recorded for 2,000 of Scotland's approximately 20,000 crofts. Research workers from other Universities are also working in this field. Dr Jaatinen's very readable general summary of the position with the illuminating examples will serve as an excellent introduction to those interested in the geography of Islands and the Outer Hebrides.

[1] *The Human Geography of the Outer Hebrides.* By Stig Jaatinen (Acta Geographica 16, No. 2) $10^{1}/_{4} \times 6^{3}/_{4}$. P.107. 23 figures. 5 plates. Helsinki, 1957.
[2] Glasgow University Department of Geography Crofting Survey.

ROYAL SCOTTISH GEOGRAPHICAL SOCIETY

REPORT OF COUNCIL

SEVENTY-FOURTH SESSION, 1957-58

(For the year 1st May 1957 to 30th April 1958)

The Council have the honour to submit the following Report :—

MEMBERSHIP

The changes during the Session are as follows :—

On the Roll at 1st May 1957		3217
New Members		714
		3931
Deduct by Death	37	
„ Resignation	720	
		757
On the Roll at 30th April 1958		3174

The fluctuation in the different categories of Membership at the four centres of the Society is analysed thus :—

	April 1957	April 1958		April 1957	April 1958
Edinburgh.			*Glasgow.*		
Life	269	266	Life	32	32
Ordinary	1177	1117	Ordinary	1028	1000
Associate	28	30	Associate	9	18
Junior	45	40			
Corporate (Schools)	17	16	Corporate (Schools)	28	28
Aberdeen.			*Dundee.*		
Life	8	9	Life	3	2
Ordinary	308	331	Ordinary	146	147
			Associate	—	1
Outside Area Members	104	121	*Honorary Members*	15	16

MEDAL AWARDS

The Scottish Geographical Medal (formerly the Society's Gold Medal) was awarded to Vivian Ernest Fuchs "for Scientific Work and Achievement in making the first crossing of the Antarctic Continent, 24th November, 1957 to 2nd March, 1958" (15th April, 1958).

The Scottish Universities' Medals were awarded to :— James Reid Coull, Aberdeen University; Malcolm Donald MacSween, Glasgow University; Elizabeth Bruce Hunter, Edinburgh University.

Fellowship of the Society

The Diploma of Fellowship was conferred upon :— (a) James Glen Harley, M.A., "for Special Services to the Society as Convener of the Lecture Committee, 1950-1957" (16th July, 1957 : (b) General Sir James Handyside Marshall-Cornwall, K.C.B., C.B.E., D.S.O., M.C., F.R.G.S., President of the Royal Geographical Society, "for Invaluable and long-sustained Services to Geography" (11th February, 1958): (c) Miss Jessie Robertson Manson, M.A. (Hons. Geog.) "for unremitting and successful Work in the Teaching of Geography in the United Kingdom and in South Africa" (15th April, 1958).

1957 Summer Tours

During the summer of 1957 136 members took part in the tour to Switzerland and Northern Italy ; 17 in the tour to Norway and 24 in the tour to the Central Alps.

Meetings of the Society

The Society held fifty-four Meetings during the Session. In Edinburgh : seven Evening Lectures in the Usher Hall ; ten Afternoon Lectures and two Evening Lectures in the Central Hall ; two Geographical Discussions in the Society's Rooms.

In Glasgow : six Evening Lectures in the St. Andrew's (Grand) Hall ; six Afternoon Lectures and two Evening Lectures in the St. Andrew's (Berkeley) Hall ; four Geographical Discussions in the Philosophical Hall ; one Children's Hogmanay Film Show ; one Lecture Luncheon and the Annual Summer Excursion.

In Aberdeen and Dundee : six Evening Lectures. Lectures are currently listed in *The Scottish Geographical Magazine.*

The Scottish Geographical Magazine

Three issues each of 64 pages have appeared with the usual number of half-tones and line blocks. The Council gratefully acknowledge a grant towards the cost of production received from the Carnegie Trust. They also record their thanks to the contributors of original papers and reviews of books. The receipt of current publications from authors and publishers is likewise much appreciated.

Library and Map Department

Additions to Library :— 263 books, of which 110 were purchased; 25 pamphlets; 4500 maps and charts.

The Council thank those who have supported the Society with the presentation of books, maps and charts.

The Society's Representatives

The following Members were appointed to represent the Society on the bodies named :—

Bruce Memorial Prize Committee—Sir James M. Wordie, C.B.E.; Patrick D. Baird.
Joint Committee for Anthropological Research and Training—Robert Kerr, O.B.E.
National Committee for Geography—Professor Andrew C. O'Dell.
National Trust for Scotland—Dr John Bartholomew. M.C., J.P.
Permanent Committee on Geographical Names—John C. Bartholomew.
Scottish National Memorial to David Livingstone—Lt. Col. John Johnston, O.B.E.
National Institute of Oceanography—Professor Ronald Miller.

Obituary

The Council regret the loss by death of Miss Jean Belfrage, Arthur B. Hyslop, Iver Salvesen, Mrs. K. M. K. Sharpley, Frank Kingdon Ward and the Rev. W. C. Galbraith.

ROYAL SCOTTISH GEOGRAPHICAL SOCIETY

REVENUE AND EXPENDITURE ACCOUNT Year to 30th April 1958

REVENUE

SUBSCRIPTIONS :		
Ordinary	£3,828	
Schools Corporate	74	
Junior	146	
Arrears	7	
		£4,055
LIFE MEMBERSHIP FEES :		
Proportion Applicable to Revenue		127
GOVERNMENT GRANT		275
Tax Ordinary Revenue		£4,457
DIVIDENDS AND INTEREST		1450
DEFICIT FOR YEAR		407
		£6,314

EXPENDITURE

MAGAZINE—Expenses of Publication (Four Issues):			
Printing	£1,540		
Editor	134		
Illustrations	115		
Wrappers, Index, Miscellaneous	15		
Postages	251		
		£2,055	
Less			
Current Magazines sold	£299		
Advertisements	177		
Grant from the Carnegie Trust	150		
Sundry Small Grants	—		
		626	
			£1,429
ROOMS—Upkeep of			
Rent, Rates, Insurance	£220		
Cleaning and Repairs	150		
Heating and Lighting	58		
Equipment and Furnishings	160		
		£588	
Less: Donations		36	
			552
LECTURES	£1,882		
Less: Tickets sold	340		
			1,542
SALARIES AND HONORARIA			1,355
AUDIT FEES			21
LIBRARY:			410
GENERAL PRINTING			421
STATIONERY AND ACCOUNT BOOKS			123
MEDALS			121
POSTAGES AND TELEPHONE			132
MISCELLANEOUS			108
			£6,314

ROYAL SCOTTISH GEOGRAPHICAL SOCIETY

PROCEEDINGS

MEETINGS OF COUNCIL were held on 23rd October and 12th December 1958.

OBITUARY: The Council records with deep regret the death of the following: Sir Ernest Maclagan Wedderburn (Vice President); the Rev. Archibald E. Robertson (Vice President); J. Allan Brown (Hon. Treasurer since 1952); John Watson (Past Chairman, Dundee Centre); Alexander R. Normand and Henry M. Paton (former members of Council).

AWARDS: The Diploma of Fellowship was conferred upon: Douglas Guthrie, M.D., F.R.C.S.E., F.R.S.E., in recognition of his services to the Society as Lecturer and Chairman of Council, and of his wide travels in lesser known countries; Professor Ronald Miller, M.A., Ph.D., F.R.S.E., for services to Geography in the academic field, and to the Society as Convenor or the Lecture Committee and Hon. Editor of the Scottish Geographical Magazine.

ANNUAL GENERAL MEETING

The Annual General Meeting was held in the Society's Rooms in Edinburgh on 7th October 1958, Dr Douglas A. Allan, President, in the Chair.

The Annual Report of Council, and the Accounts for the year to 30th April 1958 were unanimously adopted.

The following were elected:

President: The Rt. Hon. The Earl of Wemyss and March, LL.D.

Vice Presidents: Douglas A. Allan, Sir George Williamson.

Vice Presidents serving on Council: Sir Hugh McPherson, J. Cameron Smail, Douglas Guthrie, Arthur W. Russell, Alexander Harrison, John Johnston, Miss Isobel W. Hutchison and Douglas A. Allan.

Members of Council: Adam G. Brown, Lady A. M. Clow, George Dott, Arthur Geddes, James B. Hamilton, William Latimir, Miss B. P. Macfarlane, Mrs M. Lindsay Orr, Robert L. Smith, F. D. N. Spaven, J. Wreford Watson and William Watt.

Hon. Treasurer: A. A. Bremner.

The other Office-Bearers were re-appointed.

LECTURE SESSION 1958–59

The following lectures were delivered:

EDINBURGH: *Usher Hall* - Richard M. Stanley on "The Stanley Expedition 1957" on 23rd October. H.R.H. Prince Chula Chakrabongse of Thailand, G.C.V.O. on "Thailand seen by a Thai", on 13th November. Dr. C. G. M. Slesser on "The Scottish East Greenland Expedition 1958" on 4th December. Ley Kenyon, D.F.C. on "The Undersea Kingdom of Africa - The Cape to Kenya" on 11th December. *Central Hall* - Alan C. Browne, F.R.G.S. on "Irish Journey" on 29th October. J. M. Livermore on "A Short Journey to Peru" on 5th November. Miss Beryl Miles on "Candles in Denmark" on 19th November. John. B. Crawford, J.P. on "Dominion Holiday - 18 months Down Under" on 16th Novembes. Donald G. Moir, F.R.S.G.S., on "The R.S.G.S. 1958 Tour to Morocco and Spain" on 28th November. Derek R. Diamond, B.A., M.Sc., F.R.G.S., on "The American City" on 17th December.

GLASGOW: *St Andrew's (Grand) Hall* - Richard M. Stanley on "The Stanley Expedition 1957" on 22nd October. H.R.H. Prince Chula Chakrabongse of Thailand. G.C.V.O., on "Thailand seen by a Thai" on 12th November.

Dr. C. G. M. Slesser on "The Scottish East Greenland Expedition 1958" on 1st December. Ley Kenyon, D.F.C. on "The Undersea Kingdom of Africa - The Cape to Kenya", on 10th December. Children's Hogmanay Film Show on 31st December. *St Andrew's (Berkeley) Hall* - Alan C. Browne, F.R.G.S., on "Irish Journey" on 30th October. Miss Beryl Miles on "Candles in Denmark" on 20th November. Donald G. Moir, F.R.S.G.S. on "The R.S.G.S. 1958 Tour to Morocco and Spain" on 27th November. Derek R. Diamond, B.A., M.Sc., F.R.G.S., on "The American City" on 18th December.

ABERDEEN: *Y.M.C.A. Hall* - Tom Weir on "Peaks and Passes in Kurdistan" on 13th October. H.R.H. Prince Chula Chakrabongse of Thailand, G.C.V.O. on "Thailand seen by a Thai" on 10th November. Ley Kenyon, D.F.C. on "The Undersea Kingdom of Africa - The Cape to Kenya" on 8th December.

DUNDEE: *Queens College Hall* - Tom Weir on "Peaks and Passes in Kurdistan" on 14th October. H.R.H. Prince Chula Chakrabongse of Thailand, G.C.V.O. on "Thailand seen by a Thai" on 11th November. Ley Kenyon, D.F.C. on "The Undersea Kingdom of Africa - The Cape to Kenya" on 9th December.

NOTICE TO TEACHERS AND UNIVERSITY LECTURERS

Members of the Society who are teaching Geography are now able to deduct their subsription to the Society from their salary as an expense for Income Tax purposes. A member who is entitled to this deduction (it is allowed from 1958-59 onwards) should apply to his tax office for Form P.358 on which to claim the allowance. The allowance is given only salaried persons engaged in duties *e.g.* teaching or research, relating to Geography.

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GEOGRAPHY APPOINTMENTS IN SCOTTISH UNIVERSITIES, 1958

ABERDEEN: Col. P. D. Baird, formerly Senior Research Fellow, has been appointed Special Lecturer in Arctic Studies

GLASGOW: *Lecturer in Survey.*—Mr G. Petrie M.A., formerly Land Surveyor in the Colonial Survey Service, Aden.
Assistant. — Mr. A. B. Cruickshank M.A.

Lt. Col. Osborne Jelly, formerly Lecturer in Survey, has taken up an appointment with the Government of New South Wales, Australia.

EDINBURGH: *Assistant* (part-time) Mrs Cay (née Third).

★

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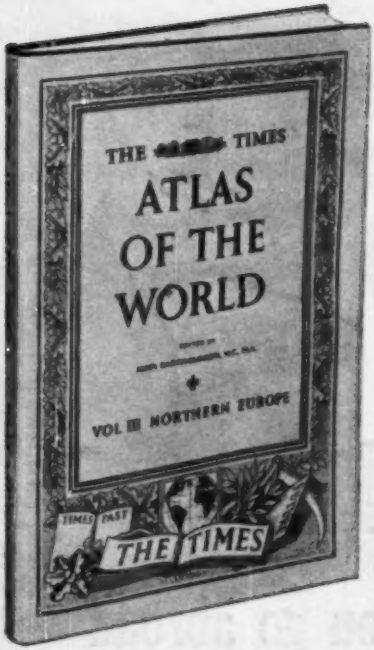

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